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THE ORTHOPAEDIC ASPECTS OF CHRONIC ARTHRITIS

The Hugh Owen Thomas Lecture, delivered before the Medical Institution of Liverpool, June 2, 1925

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Mr. President and Members of The Medical Institution of Liverpool: I have gratefully accepted your invitation to deliver the Hugh Owen Thomas Lecture, neither considering myself worthy of the honour nor well equipped for the fulfilment of the obligation. Two purposes have dictated my acceptance. The first is to express my admiration for the qualities of mind and heart possessed by the great character in whose memory the lectureship was founded, and to acknowledge the debt of gratitude and affection which I owe to his successor and my orthopaedic master, Sir Robert Jones. The second purpose is a much more personal one. Dr. Robert W. Lovett, first John B. and Buckminster Brown Professor of Orthopaedic Surgery in Harvard University, was to have delivered this lecture. American Surgery will not forget the tender care which one of its leading exponents received at your hands during his last illness. I am deeply conscious of the fact that you are striving to do him honour by inviting the humble successor to his academic chair to occupy the place which he would have filled. No American orthopaedic surgeon exerted a wider influence on the development of this branch of surgery nor demanded higher standards of effort than he. I am fortunate in being the instru-

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ment by which a tribute to him may be expressed, and I shall be happy if you will allow me to share in this tribute.

The subject of the orthopaedic aspects of chronic non-tuberculous arthritis has been chosen, first, because chronic joint disease merits all the attention which may be directed toward it. Mr. Kerr[1] has recently stated that the invalidity due to these conditions costs approved relief societies in Great Britain nearly one million pounds a year and is responsible for the loss of over one and one-half millions of weeks of labor annually. Second, because there are certain aspects of these widespread and crippling affections which in respect of functional treatment come within the purview of orthopaedic surgery; and, third, because these conditions have been of almost chief concern to the immediate group of professional associates with whom my pleasant lot has been cast.

We would emphasize the clinical nature of our discussion, disclaiming at the outset any significant share in the experimental or laboratory investigation which has clarified our conception of these diseases or types of disease and which we earnestly hope will eventually make our treatment less empirical and more rational.

We still in many cases lack conclusive proof of the specific nature of the infections, if indeed they be infections, which draw the first strokes of clinical pictures eventually very similar. We still lack accurate knowledge of the abnormal physiological processes and bio-chemical derangements which as primary factors initiate or as secondary factors prolong the symptom complexes with which we are familiar. Therefore, while we recognize the importance of placing the emphasis upon investigation and not upon therapy, we shall strive to rationalize the knowledge of the morbid processes which we possess and apply this knowledge to a functional therapy. We are conscious of the fact that any answers to the problems which we may propose, will be the result of the simple process of adding these bits of knowledge together, unable to multiply the sum by any factor of original work, but striving to apply this knowledge to the orthopaedic treatment of these disorders, the etiology of which is not so conclusively proved as to serve as an infallible therapeutic guide.

NOMENCLATURE

Let us not fall into the still common error of thinking of all cases of deforming arthritis as representing different manifestations of the same disease, protecting our diagnostic heads by the shelter of the impressive name of Arthritis Deformans. Even if we are convinced that there is a

common etiologic factor, infection, we shall not advance as fast either in our investigation or our therapy if we adopt the attitude of Peter Bell. "A primrose by a river's brim a yellow primrose was to him, and it was nothing more." We must recognize at least two clinical types running so true to form and exhibiting such distinct characteristics that they demand a separate nomenclature. Since no entirely satisfactorily descriptive terminology has been yet suggested, we direct your attention for a moment to a chart on which under headings of the commonly understood British terminology of Rheumatoid Arthritis and Osteo-Arthritis, a few of the more important attempts at classification have been synonymized. Goldthwait and Swaim, my co-workers, believe that the Rheumatoid Type should be subdivided into those which are probably due to a specific infection which they call Infectious Arthritis, and those in which atrophic bone and joint and muscle changes occur very early, seemingly not wholly dependent upon disuse and suggesting a real but undefined neurotrophic factor. Strangeways[81] has recognized pathologically six types of arthritis which in Great Britain are often included under the name of Rheumatoid Arthritis. We shall adopt in this paper the terminology which is most commonly applied in Great Britain and speak of these two types of disease as Rheumatoid Arthritis and Osteo-Arthritis.

We will next direct your attention to charts on which the main contrasting differences in the two types are briefly recorded.

I am venturing to show a few lantern slides in order that we may begin the discussion of these types with their histological and clinical characteristics freshly in mind. I realize that to bring coals to Newcastle would probably not be more futile than to attempt to furnish orthopaedic light to Liverpool. (See Figs. 1–16 incl.)

Having reviewed what seems to us the essential differences in the morbidity of these two types, we have felt it important to review some of the investigations which have had as their goal the discovery of the etiological factor or factors which may be held responsible for the onset and course of the disease. We shall consider first the Rheumatoid Type.

RHEUMATOID ARTHRITIS

Etiology

Infectious Theory. To most investigators, at first sight no etiologic theory seems so probable as the infectious theory. Many investigators, after carefully reviewing the evidence, still believe that this theory offers the most attractive and hopeful explanation of the pathologic findings

NOMENCLATURE
CHRONIC NON-TUBERCULOUS ARTHRITIS

Authors	Rheumatoid Arthritis	Osteo-Arthritis
Adams 1857[2]	Polyarticular Type	Monarticular Type
Charcot 1881[3]	Rapid Evolution. Age incidence 16–30. Little new formation of bone.	Gradual Evolution. Age incidence 40–60. Hyperostosis. Heberden's nodes. Malum Coxae Senilis.
Garrod 1890[4]	Rheumatoid Arthritis *a.* Acute Still's Disease *b.* Chronic	Osteo-Arthritis
Bannatyne 1896[5]	Rheumatoid Arthritis. Early	Rheumatoid Arthritis. Late
Goldthwait 1904[6]	*a.* Infectious Arthritis *b.* Atrophic Arthritis	Hypertrophic Arthritis
Nathan 1906[7]	*a.* Acute Infectious Arthritis (inflammatory) *b.* Insidious Autotoxic Arthritis (trophic)	Insidious Progressive Osteo-Arthritis (trophic), Senile Arthritis, Heberden's nodes, Malum Coxae Senilis. Tabes Dorsalis, Syringomyelia, etc.
Pribram 1907[8]	*a.* Chronic Pseudo Rheumatism *b.* Chronic Secondary Articular Rheumatism *c.* Rheumatoid Arthritis	Osteo-Arthritis Deformans
Hoffa and Wollenberg 1908[9]	*a.* Secondary Chronic Articular Rheumatism *b.* Primary Progressive Polyarthritis. "Arthritis Destruens"	Osteo-Arthritis Deformans
Llewellyn Jones[10] and other British Authors 1908	Rheumatoid Arthritis *a.* Acute *b.* Subacute	Osteo-Arthritis
Nichols and Richardson 1909[11]	Proliferating or Ankylosing Arthritis	Degenerative or Non-Ankylosing Arthritis
Osler & McCrae[12] System of Med.	*a.* Lesions principally in synovial membrane *b.* Atrophic changes in cartilage and bone	Hypertrophy and Overgrowth of Bone
	Type I	Type II
Ely 1914[13]	Primary Proliferation of Synovial Membrane and Marrow Secondary Atrophy of Cartilage and Bone	Primary Inflammation of Synovial Membrane and Degeneration of Synovial Membrane and Marrow. Secondary Hypertrophy of Bone and Cartilage
	Type II (Synovial)	Type I (Chondro-Osseous)
Fisher 1923[14]	Primary Synovial Membrane Invasion Secondary Cartilage and Bone Invasion	Primary Cartilage and Bone Invasion Secondary Synovial Membrane Invasion
	Type III (Mixed)	
	Simultaneous Invasion Synovial Membrane, Cartilage, and Bone	
	Spondylitis Deformans	
	"Poker Back"	Osteo-Arthritis[17]
	Spondylose Rhizomélique[15]	Hypertrophic Arthritis
	Strümpell-Marie Type[16]	Von Bechterew Type[18]

DIFFERENTIAL DIAGNOSIS

	Rheumatoid Arthritis	Osteo-Arthritis
Age Incidence	Infancy to Middle Life	Middle Life to Old Age
Onset	Acute to Insidious	Subacute to Ignorance of Presence
Joint Manifestations	Periarticular and articular swelling. Often free fluid. Early limitation of motion considerable. In hands midphalangeal and metacarpophalangeal joints usually involved first.	No periarticular and usually only localized articular swelling. Rarely free fluid. Little limitation of motion until late. In hands terminal joints usually involved first.
Symptoms	General health usually less robust. Ptotic type. Pain and disability usually more marked.	General health usually robust. Well nourished type. Pain and disability usually less marked.
Early Roentgenogram	No discoverable cartilage or bone changes. Shadows of excess of fluid and general increased density of soft parts.	Early slight "lipping" of articular margins. Shadows of localized synovial membrane proliferations may or may not be seen.
Late Roentgenogram	Diminished density of bones. Usually absence of hyperostosis. Narrowed articular cartilage space. Ends of bones fairly regular in outline. Bony ankylosis common.	Except after long disuse no diminished density of bones. Presence of marked hyperostosis. "Joint mice." Narrowed articular cartilage space. Ends of bones irregular in outline. Bony ankylosis rare.
Temperature	In early stage often slightly elevated. In late stage often subnormal.	Normal
Blood Pressure	Usually lower than normal for age.	May be low, but usually normal or high for age.
Morbid Histology	Early proliferation of synovial membrane. Pannus. Usually small round cell infiltration. Late atrophic and destructive changes in cartilage and bone. No cyst-like cavities in ends of bones. Fibrous or bony ankylosis common.	Early fibrillation of cartilage. Chondro-osseous hypertrophy at articular margins. Rarely small round cell infiltration. No general synovial membrane proliferation: separate villi. Late degeneration and loss of articular cartilage. Changes in shape of articular ends. Eburnation of articular ends. Cyst-like cavities in ends of bone. Bony ankylosis rare.

and the clinical pictures. We know that a chronic Neisser infection may be associated with a chronic polyarticular affection in which the joint tissue changes are fairly typical of Rheumatoid Arthritis. Gonococci have been found in these joints.[19] The disease has been arrested and in early cases cured by the eradication of the deep foci of the primary infection.[20] We have all of us known similar recoveries to have quickly followed the removal of other foci of infection in the tonsils, teeth,[21] sinuses, and intestinal canal.

FIG. 1
Rheumatoid Arthritis. Contractures and atrophic changes.

Poynton and Paine,[22] Beattie and Yates,[23] after careful experimental work became convinced of the bacterial origin of acute polyarthritis. Rosenow,[24] in thirty-five out of thirty-eight cases of arthritis, isolated organisms from glands draining arthritic joints, and injecting these cultures intravenously into dogs, believed that he demonstrated their affinity for joints, attributing (*nota bene*) some of the subsequent joint changes, however, to the shutting off of the blood supply to the joints by endothelial vessel changes caused by the organisms. It is to be remembered that Axhausen[25] had produced similar joint changes by simple ligation of the

joint vessels and that Manteuffel,[26] by freezing and congesting the articular ends, had observed the disappearance of the cartilage and a fibrous ankylosis. Nathan,[27] after inoculation of animals' joints with pneumococci, staphylococci, haemolytic streptococci, found it impossible to say

FIG. 2

Early Rheumatoid Arthritis. Absence of articular spaces in [wrist, showing destruction of cartilage and erosion of bone. No hypertrophic bone changes.

positively that the changes observed in the joints were due to the infection once the process was started.

Schüller,[28] Bannatyne, Wohlman and Blaxall,[29] White,[30] Fayerweather,[31] and other investigators have all found bacteria within the joint tissues sometimes culturable outside the body, but these invaders

have represented many different types of organisms, and in general, inoculation experiments have been inconclusive. In the type of disease we are discussing, the joint fluids almost constantly show no growth on culture,

FIG. 3

Rheumatoid Arthritis. Knee joint, femoral condyles, articular surface of patella, joint cavity and upper cul-de-sac. Extensive proliferation of synovial membrane tabs and villi. Beginning erosion of articular cartilage. Specimen Warren Museum.

and inoculations with various types of bacteria have, as far as we are aware, never produced articular changes typical of Rheumatoid Arthritis.

Thus it would seem that on the present evidence we have no conclusive proof that any known specific organism which invades and continues to inhabit the joints themselves can be held solely responsible for

the disease. Burbank and Hadjopoulos[32] think they have developed a method of sufficient sensitiveness and specificity for the serologic study of infective arthritis. In one of the types of the disease which they describe analogous to, if not identical with, the Rheumatoid Type, the foci which furnished the most satisfactory antigens were obtained from the tonsils, the prostate, and the intestinal canal. The organisms which

FIG. 4

Rheumatoid Arthritis. Marked proliferation of chronic inflammatory tissue (pannus) at expense of cartilage which is imprisoned and being destroyed. Magnification 80.

they hold responsible in this type are the streptococcus haemolyticus usually in the early stages, and the streptococcus viridans in the later stages. They are encouraged by the results of treatment with the vaccines which are indicated by their tests.

Billings, Coleman and Hibbs[33] believed also that the commonest etiologic organisms in these cases were non-haemolytic streptococci, but of 229 patients receiving vaccines, only 17 per cent. recovered, and of 164 patients not receiving vaccines, 17 per cent. also recovered. Schloss and

Foster,[34] although able to produce a polyarthritis in monkeys by injections of streptococci into the blood, found that these organisms were soon killed by the blood, and repeated injections seemed to produce an immunity. Swift and Boots[35] have been unable to sensitize the joints of rabbits by injections of small doses of killed non-haemolytic streptococci

FIG. 5

Rheumatoid Arthritis. Articular surface. Low magnification, 20. Alterations in cartilage-staining quality, probably attempt at new bone function: irregularity in shape, size, and position of nuclei. Attempt at new cartilage formation in a bed of white fibrous tissue. Adjacent chronic inflammation.

or their extracts. Subsequent intravenous injections of homologous living bacteria produced involvement of the untreated as well as the treated joints in the same animal.

We are beginning to accumulate suggestive evidence of the important part which faulty alimentation may play in the production of chronic arthritis. Woodward and Wallis[36] and Baldwin[37] have shown a low hydrochloric acid in the gastric juice in cases of Rheumatoid Arthritis,

and Clark[38] has found a very close association of gastro-intestinal derangements with the same disease.

Pemberton[39] has made a series of close observations which show that in general these patients have a lowered sugar tolerance and a sort of carbohydrate intolerance. They do best on diets in which the carbohydrate calories are cut down to the lowest level which can be maintained

FIG. 6

Rheumatoid Arthritis. Arteritis obliterans. Chronic inflammation. Magnification 80.

without loss of weight. Fletcher[40] has recently confirmed these observations on 150 unselected cases. Pemberton,[41] studying 400 early war cases segregated in one of the army base hospitals, found that 72 per cent. exhibited possible surgical foci, but 46 per cent. of the cases recovered on a special low carbohydrate dietary and other forms of therapy without removal of their possible foci, and this was a larger percentage than those recovering after the removal of their possible foci of infection. Lindsay[42] had previously been able to find possible infective foci in only 50 per cent. of 172 cases in which a careful search was made.

Bassler,[43] in forty-five cases of chronic polyarthritis, found in thirty-five possible sources of focal infection and in ten no demonstrable foci, but the removal of these thirty-five demonstrable possible foci failed, in his opinion, to arrest the disease. Forty-four of the forty-five cases studied showed evidence of chronic intestinal toxaemia. Smith,[44] studying one hundred cases of chronic polyarthritis and performing sixty abdominal

FIG. 7

Fragment of bone. Rheumatoid Arthritis. Atrophic bone trabeculae. Absence of marrow cells. Thickening of arterial walls and fibrosis of medullary spaces. Magnification 80. Cf. Fig. 15.

operations, became convinced of an intestinal focus of infection. Abnormalities in the ascending colon near the caecum, often consisting of restraining bands, were found, and great improvement is said to have followed division of these bands or resection of the ascending colon. Taylor[45] has made a large series of roentgenological studies of the alimentary tract in cases of chronic deforming arthritis and demonstrated (he says in all the chronic cases) so-called surgical lesions in the region of the ileum and

ascending colon, Jackson's membrane, Lane's kink, chronic appendical adhesions, etc. Nichols and Richardson,[11] approaching the disease by a careful investigation of the morbid histology of material obtained from sixty-five early and late cases of chronic arthritis, came to the conclusion that the changes which they observed in the Rheumatoid Type might result from a great variety of irritants, such as infections, disease, and

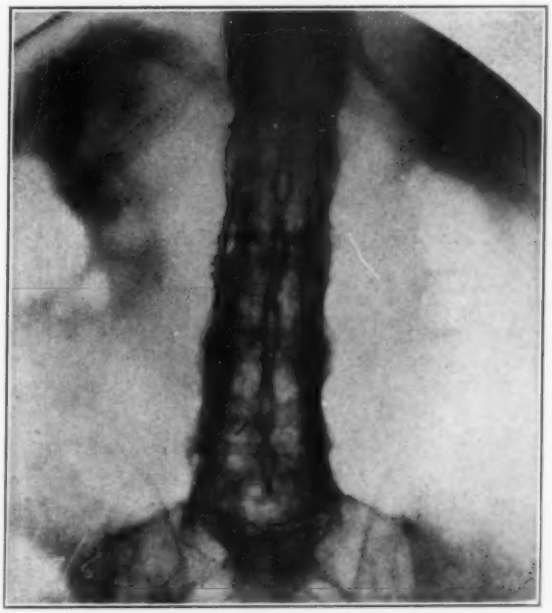

FIG. 8

Spondylitis deformans, Strümpell-Marie type. "Poker back."

trauma. Excluding the frankly suppurating and gonococcal joints, they were unable to isolate any micro-organisms, and believed that the clinical and pathologic manifestations suggested some form of faulty metabolism as the probable cause. They suggest that the primary changes once produced may act in a vicious circle with or without the primary cause continuing to be active.

These observations are at variance with Ely's[13] and the more recent careful study of the morbid histology made by Mr. A. G. T. Fisher,[46] a

strong advocate of the infectious theory of etiology, to whom the small cell infiltration usually seen, seems strong evidence of an inflammatory process. Since careful and seemingly thorough experimental and laboratory study of the disease has not been thus far completely illuminating, it may be well to turn to the clinical aspects of the condition in a search for etiologic light.

FIG. 9

Osteo-arthritic hand. Well marked Heberden's nodes on terminal phalangeal joints.

One of the most interesting of these clinical observations in consonance with the vicious circle hypothesis of Nichols and Richardson is the study which Parker[47] has made of his own case. He noticed, first, a septic focus in the mucous membranes of the nasopharynx and a faulty alimentation, he thought from swallowing infected material; then, second, vasomotor disturbances; third, a lessened resistance to infection in his nasopharyngeal mucosa, and, fourth, greater disturbances of alimentation by continued

swallowing of the infected material. When by careful diet and attention to proper elimination and autogenous vaccine treatment his alimentation was improved, his vasomotor disturbances disappeared, his nasopharyngeal infection was less active, and his joints became less swollen and painful.

Our own clinical observations lead us to believe with Garrod[48] that

FIG. 10

Well marked osteo-arthritic changes in terminal and several mid-phalangeal joints. Hypertrophic bone changes, irregularity of joint contour, but no bony ankylosis.

everything which causes debility or loss of tone to the articulation acts as a predisposing cause, and with Pemberton[49] that probably a variety of factors influence the substratum, *e.g.*, various types of infection, exposure to wet and cold, intestinal disturbances, endocrine imbalance. Pemberton[50] also believes that the changes found are associated with a low blood supply (Fig. 6) and disturbances of capillary control. Lambert's[51]

findings of a frequently lowered blood pressure in 147 cases of Rheumatoid Arthritis tend to confirm this theory.

One other clinical observation to which Goldthwait[52] has directed attention and which has impressed us greatly has been the common incidence of the disease in the so-called congenital visceroptotic type of individual, Treves'[53] and Bryant's[54] carnivorous type and Bean's[55] hyperontomorph. The female sex is more susceptible to ptosis and to the disease than the male, but in both sexes the type runs surprisingly true. Poor body mechanics, vasomotor changes, faulty alimentation, endocrine disturbances, general lack of resistance to infection, and lowering of the vitality, perhaps worry and mental strain,—these seem to us the predisposing clinical factors, and the joint changes once initiated may continue to progress until by some means, removal of serious focal infections, restoration of endocrine balance, relief of imperfect alimentation, correction of bad body mechanics, this general resistance can be raised, the lowered blood supply to the joints and the disturbance of capillary control overcome, and the complicated parts of the body machine coaxed again to function in harmony.

We have been unable positively to identify Still's disease as a separate entity. The disease in children seems to present certain peculiarities; for example, frequently a more general glandular enlargement and a more profound constitutional disturbance. No specific etiology has been worked out and faulty alimentation is most often, we believe, the most favorable point of attack. Byfield[80] believes that in these cases of chronic arthritis in children, the tonsils and adenoids are the most likely sources of infection up to three years of age; that after three the nasal sinuses are by far the most important possible toxic sources. Satisfactory recovery is by no means rare in cases seen early and the arrest of the disease frequently takes place. We must not mistake, however, the common remissions for recovery. It is a severe affection in children, but in our experience rarely fatal and may not be even permanently crippling.

THERAPEUTIC INDICATIONS

We do not feel that the general experience of clinical observers with vaccines and non-specific protein therapy has, by and large, been as hopeful in respect of permanent cure as the earlier reports suggested. Our own limited trial of these methods is in accord with this general experience. The recent interesting articles of Professor Stockman[56] and Dr. Campbell[57] of Glasgow are more encouraging. They used four in-

travenous injections of standard typhoid vaccines in dosage of from 125–200 million and always sought to obtain a fairly severe constitutional reaction. Of seventy cases studied, fifty-eight received benefit, over 80 per cent. In forty, or 57 per cent., the disease seemed arrested, sixteen suffered relapse, but were all well advanced cases. It may be that methods of Burbank and Hadjopoulos to which we have referred will furnish us with more accurate and therapeutically successful material and dosage.

We do not feel that the surgical removal of possible foci of infection with some reservation as to those of the intestinal canal has been followed in the majority of cases by the amelioration of symptoms for which we had hoped and which the patient had been led to expect; surely not in the well advanced type of case which usually in our country consults the orthopaedic surgeon. It is quite possible that our own viewpoint is prejudiced because only those patients are bold enough to consult us who have exhausted other known means of relief, but certain it is that most of them come sans teeth, sans tonsils, and unfortunately, sans recovery.

Let us not be misunderstood. It is of indubitable importance to eradicate surgically or medically any focus of infection which may reasonably be held responsible for any lowering of the general resistance, just as it is of greatest importance to adjust any discoverable endocrine disturbance or correct the faults of body mechanics. We suggest, however, that the reason for these procedures be made clear to the patient and that, remembering our clinical experience, we stay the surgical and dental hands of our confrères unless they can assure us that the foci of infection are affecting the general health of the patient and *are not simply themselves expressions of a lowered vitality for which there are other causes.* If we expect joint recovery to follow the removal of even well demonstrated possible foci, in a large proportion of the cases we shall find "Hope such a poor virtue that disappointment pays her debts." We must not be deceived by the immediate amelioration of subjective symptoms and even objective signs which follow the sudden changes in metabolism which anaesthesia and the intravenous injection of the non-specific proteins bring about. We ourselves were deceived at first by the happy changes which for several days or weeks followed the surgical removal of possible foci, until with the patients' consent, we profoundly etherized several of them and did nothing else. The immediate betterment was as striking and, alas, as temporary as that following the surgical operations on suspected foci.

There is much to suggest that the path is very open by which bacterial or chemical toxines may pass from the intestines, especially the colon, to

the joints, and we urge most careful attention to normal evacuation of the bowels by means of mechanical correction of ptosis, abdominal massage, colonic irrigation, non-irritating catharsis by agar agar and oil preparations by mouth, and in certain cases perhaps by abdominal exploration of the caecum and ascending colon. A daily movement of the bowels naturally or artificially produced does not necessarily mean a safe evacuation. The rate of passage of the food content may be, as Burnett[58] has shown, too rapid for proper assimilation and absorption. In the majority of these cases we believe the rate to be too slow and the bowel movement of today may represent that which should have been discharged many days before. Radiograms will usually demonstrate this stasis. With a person in robust health our margin of safety is very wide. Hugh Owen Thomas, carrying out his gospel of rest, was accustomed to prevent bowel movements in his important fractures for two and three weeks by his light diet of milk and arrowroot, and no harm came to his patients. These cases, however, have apparently a much narrower margin of safety and the sluggishness of their bowels may have existed for many months or years.

The rather rare case usually of short duration and fairly acute onset which recovers spectacularly after the removal of a frank surgical focus is quickly reported and too often considered the type. The case which begins to improve when it is possible to bring about a more normal rate of passage of intestinal contents and to secure a more complete evacuation of the colon is perhaps less spectacular, but we believe much more common. An illustrative and to us an instructive record has been the following:

A general practitioner of 47, seen first in 1908. An essentially negative family history. Typhoid at 14; psoriasis and frequent sore throat for seven to eight years. Overwork as illustrated by 1,000 consecutive days in his office. Some vasomotor disturbance of his hands. Bowels regular. Some loss of weight. For two or three years occasional stiffness in back and hip, after long drives. Six months before observation an acute, red, painful swelling of one toe appeared. No fever. Two weeks later one knee began to swell and gradually a typical polyarticular rheumatoid arthritis developed. Physical examination revealed a poorly nourished man. Visceral examination was negative. The urine was normal. The jaw was almost completely ankylosed. Many joints were involved by typical spindle-shaped swellings. The teeth showed no foci. The gums were a little spongy. Questionable tonsils were removed, and on histologic examination thought probably not to represent foci of infection, although cultures showed staphylococcus aureus and streptococci. No other foci were demonstrable, except possibly the intestinal canal. Thorough purgation for several weeks with copious movements was not associated with any appreciable improvement in the psoriasis or the joint symptoms. The correction of the patient's faulty body mechanics, physiotherapy to the joints, and the prevention of deformity received constant attention. In spite of this treatment he was about to return to his home with little improvement,

when one day after a colonic irrigation an unexpected, huge, very foul evacuation of the bowels occurred. There was almost immediate amelioration of the skin lesions and joint symptoms. He went into the mountains, keeping up his saline enemas, and regained his general health. A year later manipulation of several of his stiff joints under an anaesthetic restored motion. He resumed his practice in two years, which he has continued without interruption and in which he is still active in April of the present year, fifteen years after the onset of the disease. He writes that if he feels any return of his old joint symptoms, calomel and enemas and aspirin for pain will quickly cause them to disappear. His psoriasis had continued to be intermittently troublesome until he began to take thyroid extract, under which it has quieted down. The picture is almost complete: lowered general vitality from overwork and associated vasomotor disturbance; removal of possible surgical foci were without effect; physiotherapy, correction of body mechanics, ordinary catharsis with no immediate effect; colonic irrigation plus complete evacuation was followed by immediate amelioration. Attention to body mechanics, open air régime, and finally the discovery of an endocrine imbalance completed his rehabilitation. The outcome has been fortunate. He closes his recent letter as follows: "My appetite is good; I sleep well; I take things as they come, and I am quite satisfied."

Of drugs we have little to say. Aspirin and salicylates surely relieve pain and in small doses are useful for this purpose, but our impression is that in large or prolonged doses they are harmful to the digestive processes and at no stage of the disease do they seem to exert a beneficial effect on its course. In a surprisingly large number of these cases we have found the readings of the basal metabolism tests well below normal and their toleration of thyroid extract given in carefully graded doses to be considerable. "The Endocrine Element in Arthritis" by Thompson[59] is well worth perusal. Empirically we should expect and we think we have noted a betterment, sometimes surprising, by the speeding up of the general metabolism from thyroid administration when repeated basal metabolism tests have been low.

There is so much evidence to suggest that the immediate cause of the crippling joint changes is directly due to a lowered blood supply and loss of capillary control that physiotherapy in the forms of heliotherapy, active motion to toleration, non-irritating massage general and local, diaphoresis by means of low temperature steam baths, radiant light, and perhaps diathermy locally,—a fresh air and heliotherapeutic régime—are surely indicated. Occupational therapy has a great place in the treatment of these cases and special exercises often taken in recumbency, not so much of the standardized Swedish type as those designed to increase the vital capacity and relieve the ptosis, are with us prescribed as a routine. We should be unfaithful to our cult if we did not stress the great importance of prevention of deformity. Here our orthopaedic skill will be taxed to

devise apparatus, walking splints, weight and pulley traction, etc., to make sure that contractions do not occur and the greatest amount of motion shall be conserved. We warn against prolonged fixation or splinting because it still farther lowers the already low blood supply and increases the atrophy. Even a surgical giant cannot scale Olympus by "piling Pelion on Ossa."

SURGERY IN RHEUMATOID ARTHRITIS

Have we a rational surgical attack on these joints themselves? Surely not in the acute stage unless occasionally to relieve the hypertension of a joint by aspiration. Perhaps not until the disease seems well under control. Then we are inclined to believe that the local progressive intra-articular changes, especially in the cartilage, may be checked and function conserved by the operation which has been called synovectomy. Goldthwait first advocated and practised the removal of joint fringes and pannus. The operation as it is understood today was introduced, we believe, by Mr. A. H. Tubby[60] in 1908, who removed all the proliferated synovial membrane and pannus from three knee joints, with relief of local symptoms and the conservation of motion. Lately Swett[61] and Jones[62] have reported larger series of encouraging results.

In the knee joint we believe the best approach is by means of Mr. Fisher's long, vertical, para-patellar incision which affords an excellent approach to all the joint pouches. Some recent work of J. Albert Key of St. Louis, Missouri,[82] who has excised large portions of the synovial membrane of rabbits, suggests that there occurs a remarkably satisfactory replacement of the membrane, if not an actual reproduction, by a tissue which takes on all the important articular functions of synovial membrane and is fibroblastic in origin.

Is it not probably conservative surgery, when we believe the process arrested, to remove these painful villi and the mass of pannus which eventually causes destruction of the articular cartilages, before this irreparable damage has been done? (Fig. 3.) We believe it is, and that it is fair to advise an earlier surgical attack than has been in the past advised, especially upon such an important locomotive joint as the knee. If deformities have occurred and complete or nearly complete ankylosis has taken place, resection will often bring about better weight-bearing lines by depriving the joint of all motion and will establish painless function. Manipulations of the quiescent joints after the carefully outlined methods of Sir Robert Jones[63] are often of great value in correcting malposition and even restoring motion.

No successes have followed our attempts at arthroplasty on the knee joints of these wasted limbs. A flail elbow may be more useful than a stiff one in a good position, but not usually. A movable temporomaxillary joint is always better than an ankylosed one. Two stiff hips with limited or absent knee joint motion represent an enormous handicap, and while in these old cases perfect arthroplasties are as rarely accomplished in the hip as in the knee, some form of pseudoarthrosis like that of Sir Robert Jones,[64] the reconstruction operation of Whitman,[76] or even a simple excision, allows the patient limited locomotion with or without crutches and makes it possible for him to sit in a chair with comfort. It is a fearful hardship to be obliged to be continually either upright or downright. To be able to *receive* attention without *attracting* it, is a great blessing.

Extensive operations on the hip joint are serious and it is often difficult to estimate the amount of shock which may follow. We have found the following plan of procedure easy to carry out and fairly rapid in execution. Painless motion has persisted and the stability has been greater than we had expected. An anterior vertical incision from the anterior superior spine downwards for five inches; the sartorius and rectus are defined and retracted to the medial side, the tensor fasciae latae to the outer. The hip joint capsule, acetabular rim, and the femoral neck to the intertrochanteric line are thoroughly exposed. A large U-shaped flap of capsule which is always adherent to the anterior femoral neck is separated and turned up. The posterior portion of the capsule is separated from the femoral neck by a periosteum elevator from the acetabular rim to its distal attachment to the femoral neck. The neck of the femur is next removed after its division by means of the Gigli saw or osteotome at the acetabular rim and at the intertrochanteric line, the ankylosed head remaining in the acetabulum. The anterior and posterior thick flaps of capsule, ample in size, are next stitched together over the raw surface of the acetabulum and the limb put up in splint or plaster in moderate abduction.

Five hips thus operated upon have had 60 degrees to 90 degrees of painless motion at the end of two or more years and have been unexpectedly stable.

SPONDYLITIS DEFORMANS

In discussing spondylitis deformans we have placed under the caption of Rheumatoid Arthritis that form described as the Strümpell-Marie

type, the so-called spondylose rhizomélique, or "poker back." There is little chondro-osseous proliferation, but a gradual ossification of the spinal ligaments and intervertebral capsules resulting in a complete bony stiffening of the spine and an ankylosis of the costo-vertebral articulations. There is also frequently a fusion of the root joints, the shoulders and the hips. Our present knowledge would lead us to discuss its etiology as we have discussed the etiology of the general type of Rheumatoid Arthritis, recognizing the fact that this crippling spinal affection has frequently been observed to follow an infection of the prostate gland.

The therapeutic indications we consider to be the same also as those of Rheumatoid Arthritis.

The orthopaedic aspects are of great importance. The early signs of this vertebral affection are definite,—limited motion of the column and diminished chest expansion. We should never fail to recognize these early signs. The progress of the disease is often difficult to check, but the prevention of deformity is not difficult. If the intervertebral and costo-vertebral articulations are to ankylose, we must see to it that they ankylose in such a position that the action of the thoracic viscera, the lungs and heart and diaphragm shall suffer the minimal interference with their function. Again, attention to body mechanics should be our first concern. It is often possible, even after marked degrees of stiffening have occurred, to increase greatly the capacity of the thoracic cage by means of enforced positions, exercises, braces, and corrective jackets. We have even hazarded forcible manipulations under an anaesthetic in cases of great deformity, and have known of fatal outcomes from this procedure more immediate but not more inevitable than the pulmonary and cardiac complications to which these untreated patients fairly speedily succumb. Long and by no means intolerable life is possible with a completely rigid spine if the lungs and heart are allowed space in which to function and the diaphragm in which to act (Fig. 8).

OSTEO-ARTHRITIS

Etiology

The type of chronic Non-Tuberculous Arthritis which is generally designated in Great Britain as Osteo-Arthritis and is more often spoken of in America as Hypertrophic Arthritis, demands less discussion as to its etiology than the Rheumatoid Type for, unfortunately, it has been the subject of less thorough investigation. Cases manifesting its distinct characteristics have frequently been included in experimental and clinical

studies and, therefore, much that has been said in the review of the work on the etiology of Rheumatoid Arthritis applies to a discussion of the etiology of Osteo-Arthritis.

Climatic conditions offer little clue to its causation. As in Rheumatoid Arthritis,[65] the tropics and the bipolar regions seem to furnish few examples of the disease. Exposure to cold and wet is a less frequent history than in the first type. Lowered general vitality is rarely demonstrable before the onset. Definite trauma is often prominent in the patient's mind, and repeated unnoticed traumata and the malalignments of joint surfaces, the "incongruence" of Preiser,[66] can often be found for the searching. Intra-articular fractures are usually followed by such changes.

Except for the rather rare, frankly traumatic case the age incidence is striking. It is a disease of middle or late life and is no respecter of persons or sexes or social standing. The early joint changes which are obvious to physical examination and roentgenologic study are slight or moderate localized joint swellings, ridging of the articular ends, chondro-osseous overgrowths at the margins of the cartilage. Eventually if the process is unchecked the articular cartilage disappears, leaving an eburnated bone end often irregular in contour, interlocking but not uniting with its opposing joint element. They are called Heberden's nodes in the fingers, malum coxae senilis in the hip (Fig. 11), and ring bone in the spine (Fig. 19). Nichols and Richardson[11] found the earliest changes to consist of a fibrillation of the cartilage (Fig. 14). Ely[67] believes the essential process to be an aseptic necrosis in the bone marrow of the articular end near the surface (Fig. 12), the original infection having died out. He considers the eburnation of the surface of the bone end an attempt of nature to wall off the process from the joint. Fisher[14] thinks that the quality of the synovial fluid first changes with pitting of the articular cartilage and proliferation of the cells as from an irritant. Osteo-Arthritis, he says, is "not a disease but a series of pathologic and physiologic changes in a joint subject to prolonged and repeated injury either mechanical or toxic of moderate intensity." Ely believes the changes are induced by an infection, holding alveolar foci responsible and reporting the discovery of amoeboid cells in the cyst-like cavities (Fig. 12) of the ends of a freshly excised femoral head. Kofoid and Swezy[68] found amoeboid cells in Ely's specimen, but interpret the form as the endamoeba dysenteriae and not as the endamoeba gingivales of the teeth and tonsil. They think that the amoeba of the bone is usually the endamoeba dysenteriae. Fisher thinks[46] also that Osteo-Arthritis may be caused by bacterial toxines either formed locally or more probably brought from

some distance, but he admits the frequent occurrence of the traumatic, idiopathic, spontaneous and senile form, and says that "a striking feature and one which distinguishes the disease from the more acute and probably infectious Rheumatoid Arthritis is the almost invariable absence of small

FIG. 11

Osteo-Arthritis hip joint. Malum coxae senilis, marked, hypertrophic changes in head of femur and in acetabulum accompanied by degenerative changes and eburnation, entire loss of cartilage, but no ankylosis, articular contours entirely changed. Specimen Warren Museum.

cell infiltration." Nichols and Richardson[11] found no evidence of leucocytosis or an inflammatory exudate. Joint fluid and tissue examinations have usually revealed no organisms. Clinically the joint disturbances under discussion do not often suggest any inflammatory process, certainly not as much as the disturbances in gouty joints, for which we hold not an infection but faulty body chemistry responsible.

There is some evidence to support the etiologic theory of faulty body chemistry. Haygarth,[69] and recently Cecil and Benjamin,[70] have called attention to the fact that many cases of this type appear at about the time of the menopause in women and Cecil has observed this to be true in

FIG. 12

Osteo-Arthritis. Cystic cavity in head of femur. Specimen Warren Museum.

certain patients in whom an artificial menopause had been induced. Cecil could establish no relation to possible alveolar foci, many of his patients having had all their teeth extracted years before the onset of the trouble. McCrudden's[71] early work seems to indicate a tendency in these cases to an abnormal retention of calcium.

Our experience has not been that of Mr. Fisher, that the removal of

surgical foci has favorably influenced the condition of the joints, unless these foci were profoundly affecting the general health of the patient. Rheumatoid Arthritis usually appears in the light, ptotic, carnivorous type, the hyperontomorph of Bean.[55] Osteo-Arthritis usually appears in the heavy, herbivorous type, the hypoöntomorph of Bean.[55] As the patients

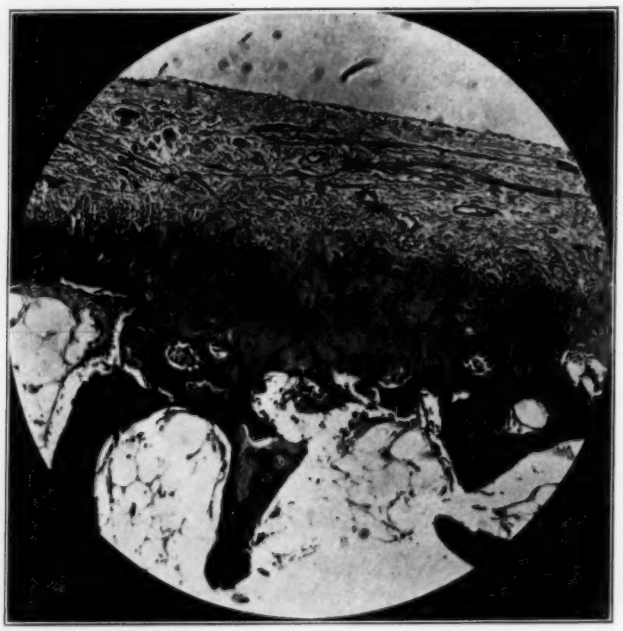

FIG. 13

Traumatic chondro-osseous spicule. Transition from connective tissue to cartilage and bone. Capillary formation and slight perivascular lymphocytic infiltration. Rarefaction of bone. Proliferation of connective tissue cells along smooth edge. Articular cartilage invasion, absence of small cell infiltration. Magnification 80.

usually present themselves, they describe their general health as excellent and their appearance does not belie their words. They have been active men and women, the digestion has been excellent, the bowels usually fairly regular, the weight is often above normal, but one or more of the joints are beginning to "bother" them and to interfere with activities for the pursuit of which they still feel a zest.

THERAPY

The orthopaedic aspects of this type of chronic arthritis are more striking and of even earlier concern than in the Rheumatoid Type. They may be said to present themselves at the very earliest sign of the onset of the process. The local therapeutic indications are to maintain and stimulate the blood supply of the joint by heat and massage *about, but not on,*

FIG. 14

Osteo-Arthritis. Fibrillation or fragmentation of articular cartilage. Magnification 80.

the chondro-osseous ridges, and by intermittent active, painless motion, but not by manipulation. First and foremost, we must diminish in every way intra-articular friction. We are quite in accord with Mr. Fisher's views as to this necessity.

These joints do not ankylose except in the spine and pelvic joints, where one chondro-osseous spicule directly impinges upon and finally fuses with another (Fig. 19). We need not fear that fibrous or bony fusion will

result from even complete immobilization. The spicules and ridges of bone at the articular margins which the Roentgen ray reveals are capped by a sensitive cartilage which proliferates from the irritation of frictional motion. Protect the sensitive ridge, limit joint motion, or even temporarily completely deprive the joint of motion, and the irritation will subside. The roentgenogram later will show no change, but the patient

FIG. 15

Fragment of bone, Osteo-Arthritis. Absence of marrow cells. Hypertrophic or gigantic bone trabeculae. Slight infiltration of medullary fat. Magnification 80. Cf. Fig. 7.

will often declare himself completely relieved. If he is willing to restrict his activities to the limit of non-irritating use, his joint function may represent the least of the incapacities of his increasing age.

This rest and protection of the affected joints with painful active or passive motion always discouraged we believe to be our first therapeutic indication, although it is a purely local one. The next indication is a more general one and has to do with body mechanics. We should strive to bring

about as perfect an alignment of the weight-bearing mechanism as it is possible to attain. This may mean the relief of knee strain by the correction of pronated feet, the relief of low back and hip strain by the adequate support of a pendulous abdomen, the neutralization of dorsal and shoulder girdle and cervical strain by suitable braces. Do not understand us as advocating these initial measures as of more importance than an attempt

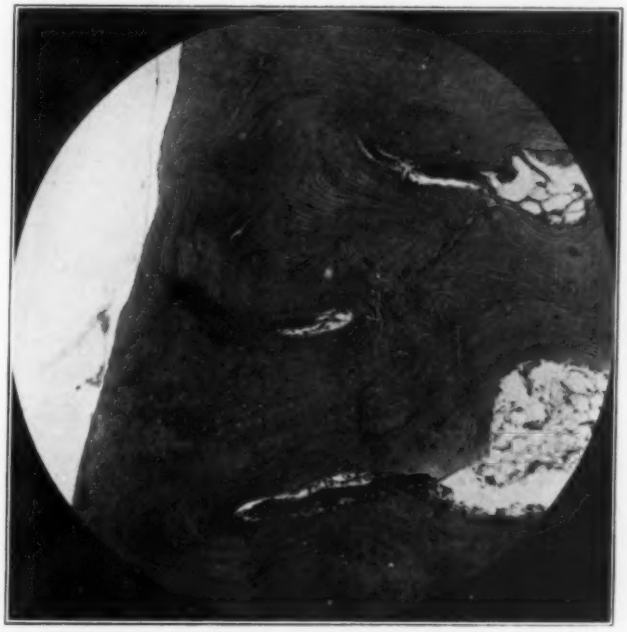

FIG. 16

Osteo-Arthritis. Dense eburnation of articular surface. Magnification 80.

to discover the underlying bio-chemical cause of the joint changes. This is, of course, our ultimate goal, but our initial endeavor should be at the earliest moment to prevent by local measures, processes which to many of us seem essentially degenerative from being accentuated by wear and tear.

We have not observed sudden spectacular relief to follow the correction of intestinal stasis, but we believe the process may be checked and held in abeyance by securing a more perfect elimination than the patients themselves often accomplish unaided. To favor this increased elimina-

tion, the methods previously described are applicable, steam baths, non-irritating catharsis by mouth, abdominal massage, colonic irrigations, if the colon empties sluggishly. We all have our favorite drugs and ours is the non-effervescent phosphate of soda. We have no proof, but a strong impression, that the joint process becomes less active during its administra-

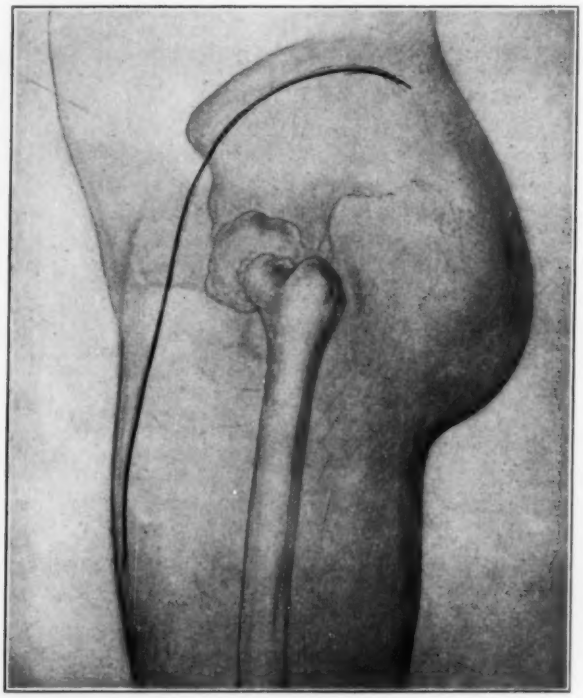

FIG. 17

Smith-Petersen approach to hip joint. Line of skin incision.

tion. Diet does not seem to influence the joint conditions as frequently as in the Rheumatoid Type. They are not controlled by even a strict vegetarian régime, but in general the patients do better on a low protein and fat intake, a low meat and sweet and low acid-forming diet, as do the gouty cases.

The endocrine disturbances have not been so common in this type, although we have been surprised often to find a lowered metabolism and a

tolerance of thyroid extract in many cases. In women, following the menopause, betterment has seemed to be associated with the administration of ovarian extract.

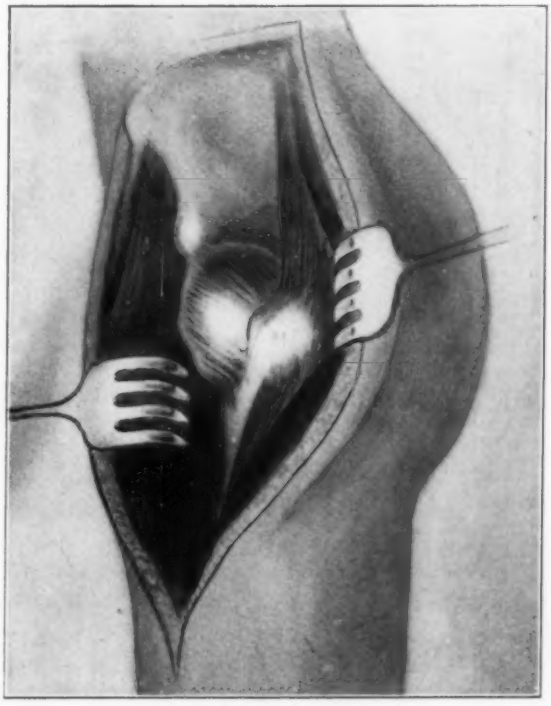

FIG. 18

Smith-Petersen approach to hip joint. Sartorius and rectus to medial side, tensor fasciae latae to outer side.

SURGERY IN OSTEO-ARTHRITIS

Surgery may offer temporary and sometimes permanent relief in difficult cases. We often hear manipulation of these joints advocated. This is justifiable in those rare cases in which contractures have taken place or malpositions of weight-bearing have occurred, and in those monarticular cases in which repeated acute attacks have left adhesions, but intra-articular adhesions are uncommon in the polyarticular cases, and in our experience forcible manipulations, save to secure better functional posi-

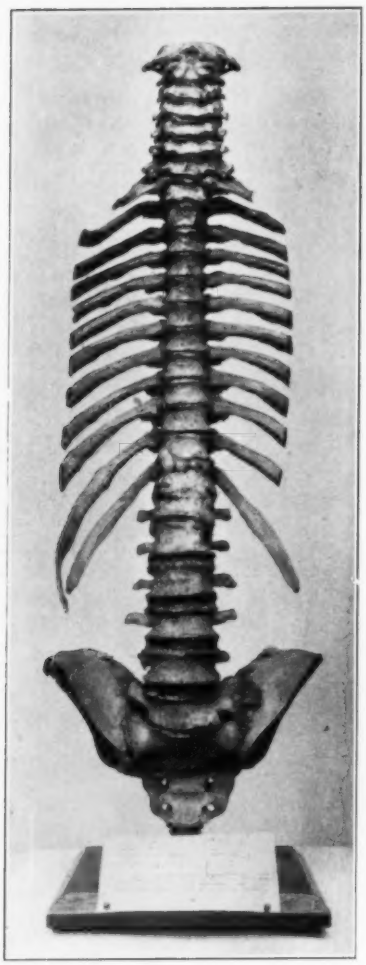

FIG. 19

Osteo-Arthritis of spine. Marked lipping of articular edges of vertebral bodies and localized chondro-osseous spiculations, some of which have fused in spine and at left sacro-iliac joint. Degenerative changes in 11th and 12th dorsal vertebral bodies. Specimen Warren Museum.

tions, have rarely afforded even temporary relief and have seemed to affect unfavorably the course of the local process. Unless prolonged fixation follows the manipulation, the old faulty position is soon reassumed. We are aware that our experience has not been that reported by other clinicians, but it is definite none the less.

Loose bodies arising from detached chondro-osteophytes or synovial membrane fringes are often greatly incapacitating, especially prone as they are to occur in the knee joint. When they are present in the posterior compartment of the knee joint their escape is shut off and the approach to the posterior compartment by a midline incision in the popliteal space[72] has proved most direct and satisfactory in our hands. Fringes which catch between the articular ends, chondro-osteophytes which impinge, often make arthrotomies justifiable, and their removal may afford a long relief without, of course, the assurance of their non-recurrence. These operations should be performed only after the disease has been rendered quiescent by a period of adequate protection. The underlying pathologic process militates against the success of nice arthroplastic operations, and because of the eburnation and cyst formation in the ends of the bones (Fig. 12), makes it difficult to obtain firm bony union after resection. Fortunately, the operation of arthrodesis is rarely indicated in any of the joints affected by the disease, the hip joint alone excepted.

Malum coxae senilis (Fig. 11) presents a special orthopaedic problem. Local protection of the other joints usually makes life tolerable, and even in the hip, if the functional position be not too bad and the patient is willing to suffer the inconvenience of a stiff spica or even some less radical protective appliance, pain and discomfort may be relieved.

In a recent discussion of this subject by the members of the British Orthopaedic Association,[73] it is fair to say that no very general consensus of opinion was elicited. Albee[74] was, I believe, one of the earliest surgeons to advocate depriving these joints of motion by the operation of arthrodesis. In the comparatively young, strong, early, and traumatic cases the procedure was successful in relieving pain and increasing function. Brackett[75] later applied the method to older and more advanced cases. In following these, it was evident (1) that operative shock was an element which must be seriously reckoned with, (2) that the nature of the bone in an old case did not make the securing of bony union an easy task, (3) that very prolonged and incapacitating immobilization following the operation was a sine qua non, and (4) that in some of the cases the original malposition recurred even after this prolonged immobilization. It is evident that if this procedure has a place in the treatment of malum coxae senilis, the

cases must be most carefully selected and the operation must at one and the same time entail the least possible amount of shock and be so thorough as to afford the greatest possible hope of securing a firm bony ankylosis.

Dr. Royal Whitman[76] has recently applied with success his reconstruction operation to cases of Arthritis Deformans of the hip joint. By a U-shaped antero-lateral approach the capsule is reached between the tensor vaginae femoris and gluteus medius. The base of the trochanter is divided with a wide chisel in the line of the femoral neck, and with its attached muscles is turned upward. The capsule is now opened and the greater part of the head removed, including all the cartilage, the marginal exostoses, and as much of the underlying bone as is involved in the degenerative process. This articulating end is made smooth and inserted into the acetabular cavity, from which no cartilage is removed. A thin section of bone with overlying muscle is turned back from the upper and outer surface of the femur, and the detached trochanter with its original muscular attachments is brought down so that its base may be apposed to the fresh, bony surface of the outer portion of the shaft, where it is fixed by sutures or a bone screw. The limb is fixed in an extended and abducted position.

Seven cases form the basis of Whitman's paper. Three he describes as typical cases of "morbus coxae senilis as to age, symptoms, and pathological appearances." The oldest of the other reported cases was forty-eight years. In one case two years have elapsed since the operation; in the others less than a year. Whitman describes the immediate results from the operation as satisfactory. "The deformity of the adducted limb and tilted pelvis has been corrected, the range of motion increased, and the pain on movement and weight-bearing has been reduced to discomfort."

We have had no experience with the arthroplastic procedures of Mr. Hey Groves,[77] in which the head is resected through a posterior incision and the extremity of the neck covered with a fascial flap reinserted into the acetabulum.

We have followed several cases in older subjects whose deformed femoral heads have been quickly resected with no attempt made to reconstruct a stable joint. Convalescence has been rapid and pain relieved. There remains the disadvantage of somewhat unstable hips. But this procedure is less shocking in the older, more feeble subjects with much misshapen heads, is a safer procedure than an attempt at arthrodesis and perhaps than any more formal or more extensive operative attack. Though I cannot speak from personal experience, I believe one of the most useful and least shocking operations in "elderly and fragile patients" is the pseudoarthrosis of Sir Robert Jones. It consists, as you know, of making

a longitudinal incision of about six inches with the upper border of the trochanter at its center. A slice of the trochanter is removed with a wide osteotome, starting from its base just below the insertion of the glutei and including its junction with the neck. The capsule is opened and the head of the femur separated from the neck with an osteotome. While extension is applied to the femur, the trochanter with its attached muscles is fastened by a screw to the base of the head which remains in the acetabulum. A painless, mobile hip is to be expected. In these older cases surgery is surely the last resort, seldom demanded and always hazardous. In some of the extreme cases in good surgical risks an attempt at an arthrodesis seems to be the method of choice.

I beg the indulgence of even so distinguished an audience if I briefly describe the type of operation which among my associates is employed.

(1) A long incision beginning on the anterior surface of the thigh about five inches distal to the anterior superior spine and extending above the anterior superior spine along the crest of the ilium for about the same distance of five inches (Fig. 17).

(2) The tensor fasciae femoris is separated, chiefly by blunt dissection from the rectus and sartorius, and retracted to the outer side (Fig. 18).

(3) The muscular attachments to the anterior superior spine and the crest of the ilium are incised to the bone, and the subperiosteal dissection of the whole muscle flap continued outward and downward until the superior and posterior margin of the acetabulum and the hip joint capsule are completely exposed and well defined. This approach has been devised by Dr. Smith-Petersen of Boston, and in our experience has proved the most complete and bloodless and least shocking of the thorough exposures of this joint.

(4) The division of the capsule and Y-ligament near the acetabular rim.

(5) The complete dislocation of the femoral head, which may now be easily accomplished without serious traumatic shock.

(6) The acetabular cavity is scraped free of cartilage remains, the bony surface incised with an osteotome, and frequently a mass of bone removed from its superior portion to provide a raw, flat roof to oppose the remodeled femoral head.

(7) The femoral head is generously remodeled by removing the osteophytic overgrowths and sufficient bone to secure a compact bleeding surface, which is shaped to fit the acetabular opposing surface in the best position for future function. Fresh bone chips may be packed into the interstices.

(8) The muscular attachments to the trochanter are subperiosteally pushed back and the superior surface of the neck denuded of periosteum.

(9) Thin flaps of bone are turned down from the ilium above and behind the acetabulum.

(10) An osteo-periosteal ribbon graft removed from the tibia (by an assistant in order not to prolong unnecessarily the operation) is laid along the neck from the denuded trochanter to the denuded surface of the ilium and may be again covered with the thin flaps turned down from this bone.

(11) The capsule is resutured, the muscle flap subperiosteally reflected from the ilium is laid back and resutured, and the subcutaneous tissue and skin brought together.

(12) A double plaster spica is applied in slight abduction, including the low thorax, the unaffected limb to the knee, the affected limb to the toes, and firm bony union is awaited with hope.

SPONDYLITIS DEFORMANS

Osteo-Arthritic Type

Under the caption of Osteo-Arthritis we have placed those forms of spinal affections described by von Bechterew, the hereditary traumatic kyphosis, and the hypertrophic arthritis of Goldthwait (Fig. 19). It differs in no way, either etiologically or pathologically, in our opinion, from the other articular manifestations of Osteo-Arthritis, except that the chondro-osseous ridges and spicules at the margins of the vertebral bodies are prone to impinge upon one another and occasionally eventually unite (Fig. 19). In subjects who bear heavy burdens on their shoulders or assume an habitual posture of stoop shoulder, a rounded, rigid dorsal kyphosis ensues. Though the intervertebral foramina themselves are usually free from osseous changes as studied in the large collection of spinal specimens in the Warren Museum of the Harvard Medical School, the chondro-osseous ridges may impinge on the nerves after their exit from the intervertebral foramina. Brachial, intercostal, and sciatic pain are, therefore, not uncommon symptoms of this disease when it affects the spine, and a localized or general rigidity of the back is nearly always present.

The roentgenograms of spines taken for suspected kidney or other visceral lesions frequently reveal well marked osteo-arthritic changes, often when the subjective symptoms of this type of articular changes are entirely absent.

The orthopaedic aspects of the condition concern us very acutely,

especially since industrial insurance and workmen's compensation cases have become so numerous.[78] A man in apparent good health and free from back symptoms changes his type of labor from one requiring little stooping or lifting to one which involves the repeated trauma of bending his back with a burden superimposed. He is soon unable to continue to so labor. The employer contends honestly that the task is not unreasonable, nor should it harm a man in good health. The man quite as honestly declares that he was free from pain until he changed his type of work and that now he suffers continually from back strain and perhaps sciatica. They are both quite correct in their statements. If we would help to adjust such cases fairly we must hold the employer partly responsible for not discovering the lessened resistance of this man's spine by a careful examination before he was employed for this type of labor. We must convince the laborer that his spine, although equal to certain tasks like those he formerly performed, was potentially weak and incapable of standing the repeated strain of back bending. Neither ought to be compelled to assume the whole debt of idle days.

We must be on our guard also against the occasional malingerer who, I am sorry to say, is met in our country and perchance in yours. When the bad weather comes he seeks an orthopaedic clinic, complaining of back pain. A roentgenogram of the spine is taken and perhaps a little lipping of the vertebral bodies is seen. Few of us escape these unimportant changes after forty-five. A plaster jacket is applied and the man is quite comfortable. It is removed in a month and his pseudo symptoms return. It is reapplied and he is happy. Thus, like the grub in its chrysalis he hibernates until better weather comes and full pay in the sun becomes more attractive than "dolce far niente" in the rain and snow on a two-thirds compensation dole.

The therapeutic indications are the same as in other types of the condition. Attention to general health and free elimination, physiotherapy, protection of the affected portion of the spine by a Thomas collar, a spinal brace or jacket, and an attempt to neutralize or correct the faulty spinal curves and bring about a normal weight-bearing alignment. Conceivably a spinal fusion operation might be a rational procedure in an occasional case. Relief from less radical measures is ordinarily easy to obtain, and for this in the commonly met cases exhibiting low back pain and sciatica the low short back brace with an abdominal supporting pad devised by Goldthwait has been a sheet anchor which has held. If rest of the affected part, diminution of intra-articular friction, free elimination can be provided, we may expect symptomatic relief.

COMMENT

The orthopaedic aspects of chronic arthritis are many. In the early stages of the Rheumatoid Type the problem is mainly one which demands the most immediate and meticulous attention of the internist. If he is successful in discovering the initial focal infection, an endocrine imbalance, the cause of the faulty alimentation, the reason for circulatory disturbance, the errors of body mechanics, he ought usually to be able to cope with the arthritic diathesis and he may entertain high hope of arresting the disease and of helping to bring about a complete recovery. I say helping, for we must not forget the aphorism of Paré, "Je le pansay, Dieu le guarit."

In the later stages when actual tissue changes have taken place, let us not think of the possible surgical focus as a sort of Cadmus sowing the dragon's teeth that represent the only armed forces that are continuing the war against the joints. Rather let us listen to Haldane[79] speaking of certain chronic diseases, "We are not likely to deal with them effectually on Pasteur's lines; we must divert our views from the micro-organism to the patient. Where the doctor cannot deal with the former, he can often keep the patient alive long enough (for him) to be able to do so himself."

With Osteo-Arthritis, also, the patient must be the first concern of the orthopaedic surgeon, remembering that the local treatment of the joint lesions offers great hope of amelioration of the symptoms for the relief of which we are consulted. Surgical foci inimical to general health should, of course, be eradicated, but if we do no more the disease may be expected to progress. If we correct an endocrine disturbance, increase the elimination, diminish intra-articular friction, insuring better joint alignment by attention to body mechanics, and occasionally resorting to well conceived surgery, we may expect reward.

No individuals deserve keener, more patient investigation than those whose joints are in travail. No more grateful patients exist than those who may receive betterment, if not anatomic cure, of their joint derangements at our hands. The difficulties in adequately caring for them are great. The outstanding demand would seem to be for professional team play. There must be a captain of the patient's fate, and whether he be the general practitioner, the skilled internist, or the orthopaedic surgeon, it matters not if all be competent. He should be chosen who has enlisted and can hold the complete confidence of his charge. Professional jealousy and false medical ethics may block the road which leads to recovery. We owe these patients fullest medical coöperation. We can make no more heartening effort than to restore a large or small amount of function to

these prevalent and appealing cripples. When we lighten their load, we lift also a wellnigh intolerable burden from the shoulders of those who must not only provide for their financial support, but administer to them the draughts of hope and courage which are potent in their healing.

SUMMARY

1. Rheumatoid Arthritis is a disease in which no specific organism has been found which can be held constantly responsible for its causation. Probably many different types of organisms and many other factors play etiologic parts in its onset and course.

2. In the early stages of Rheumatoid Arthritis, if these organisms and if the other factors can be overcome, complete recovery is possible. In the later stages, if the factors inimical to normal vitality can be eliminated and the essentials for normal body mechanics can be satisfied, arrest of the disease and great functional betterment may be expected. In this stage the simple eradication of a possible surgical focus of infection will rarely be successful in controlling the progress of the disease.

3. Osteo-Arthritis is a disease in which no specific organism has been conclusively proved to be responsible for its causation. On the basis of the present evidence its manifestations may occur unassociated with any demonstrable remote or local focus of infection.

4. In the early stages of Osteo-Arthritis, if a faulty body chemistry and a faulty body mechanics can be corrected and intra-articular friction can be lessened, almost complete relief of the subjective symptoms is possible. In the latter stages, if intelligent physiotherapy, protective appliances, and well conceived orthopaedic surgery be added to these measures, relief of discomfort and greatly improved function may be expected.

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A CONTRIBUTION TO SPINAL OSTEOARTHRITIS INVOLVING THE CERVICAL REGION*

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This contribution to the subject of arthritis is restricted to one of the expressions of the great type known as osteoarthritis, by some called hypertrophic arthritis, by others degenerative arthritis; how it implicates the spinal column in its onward march and specializes in a part of the cervical region; further, to emphasize the rational treatment of the condition and to reëmphasize the claim that we have in osteoarthritis a distinct entity.

This form of arthritis implicating the spinal column in a general way has been considered by Dr. Casamajor *et al.* of the Neurological Institute, but regarding the spinal cervical column as a selected site I believe this is the first published contribution to the subject. I have been unable to find in the literature any specific reference to it.

Forms of Arthritis Excluded. We exclude from consideration here the well known types of arthritis affecting the spinal column, such as the true infections—well represented in the gonorrhoeal form, for example,—where the vertebrae become glued together in firm ankylosis—the ankylosing spondylitis—a common end-product of certain infections. Further, spinal involvement going with the proliferative type is also excluded.

Contrasting Proliferative Type with Osteoarthritic as to Spinal Column Involvement. Those of you who have had a large experience with the proliferative type of arthritis know the infrequency with which it attacks the spinal column. To verify this we have gone from bedridden to bedridden patient with practically all of the extremity joints involved, to find a very mobile spine. Not so with the disease under consideration: the spinal column here is frequently involved.

Disease Selective. The disease appears to be selective. In my experience the cervical region is a frequent part for attack. The matter of selection does not end here. A certain part of the cervical region is selected for attack—this the lower portion. The upper vertebrae as a rule escape, as I am able to demonstrate. To Dr. Lewis Gregory Cole

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is due the credit for first having made this observation and to him I am indebted for valuable aid which enabled me to make this contribution.

Findings. The lesion is confined to the lower cervical vertebrae beginning usually with the fourth. The intervertebral discs disappear and the vertebral bodies fall forward. Deprived of their buffers, the vertebral bodies become subject to slight traumata. New bone, vulgarly called "lipping," results. Cartilage of the articular processes disappears and proliferation of cartilage occurs, followed by new bone formation. It is here, in the region of the intervertebral foramina, that the nerve symptoms arise. Exostoses of the anterior part of the bodies of vertebrae do not involve nerves. Exostoses about the intervertebral foramina give another story. The foramen is subject to narrowing in three different ways: (1) destruction of the intervertebral substance, allowing the bodies of the vertebrae to fall closer together; (2) new bone formation extending into the foramen from the edge of the bodies of the vertebrae; (3) from the articular processes of the vertebrae.

It is an anatomic fact that the posterior walls of the intervertebral foramina are formed by the articular processes of the vertebrae, and just here the pathologic process is active and throws out new bone which narrows the exit through which the spinal nerves pass. (See radiograms.) Any pushing out of tissue formation beyond the articular margin is at the expense of the foramen.

Definite Symptomatology. The symptomatology is restricted as a rule to an expression of root irritation only. In spinal cord tumors, the two chief types, the extra-medullary and the extra-dural giving root symptoms, give in addition cord symptoms,—compression symptoms. These latter are absent in the type under consideration.

It is an anatomic fact that the cervical posterior (sensory) roots are of greater diameter than the anterior (motor)—three to one, and greater than in any part of the spinal cord.

In the cases which have come under my observation pain is the prominent subjective complaint, and this in part or all of the area supplied by the fourth, fifth, sixth, seventh, or eighth cervical nerves,—respectively, part of the neck, shoulder, outer side of arm, and the forearm, chiefly the radial side involving the thumb and index finger. Subjective sensory symptoms, in the nature of paraesthesia or anaesthesia, may be present at the site of pain. The pain resembles that of a spinal cord tumor, but the differential diagnosis is not difficult, for, to the irritation radicular symptoms going with the condition under consideration, are soon added

in spinal cord tumors, cord symptoms. I may add that those having had a large experience in operating upon spinal cord tumors, Elsberg, for one, state in some few cases irritative root symptoms may for years stand alone. But to differentiate from even such, admittedly rare, we

FIG. 1

Normal Cervical Spine. Showing rather large foramina with smooth, even margins; also normal intervertebral substance.

have in the arthritic type involvement of other joints and the Heberden's nodes to confirm the diagnosis.

Symptoms may be produced or inaugurated by an injury, such as a sudden wrench or strain. It is natural for patients to attribute the origin of the malady as a whole to such injury.

REPORT OF CASES

Not to weary you with clinical reports, I beg to cite briefly one case of many that have come under my observation.

Male; aet. 56 years. Always well with exception of headaches whenever exposed to dampness. Especially sensitive to east winds coming from the sea and northwest

FIG. 2

Showing ragged bony margins of cervical foramina through which fourth, fifth, sixth and seventh cervical nerves make exit. Foramina are much narrowed.

winds in winter coming from the snow fields. About two years ago first felt aching pains about left shoulder. When he first consulted me six months ago he complained of stiffness of the neck at times, and the pain was not confined to the shoulder but radiated from time to time down the outer side of the arm and forearm, at times going as far as the thumb. The above history, together with absence of direct cord pressure

symptoms and negative findings of shoulder joint disease and bursitis, suggested to me an osteoarthritic involvement of the cervical region of the spine. The radiogram (Fig. 2) shows a new bone production impinging on the second, third, fourth, and slightly on the fifth intervertebral foramina, through which the fourth, fifth, sixth, and seventh cervical nerves make their exit. May I remind you that the third cervical nerve makes its exit through the first intervertebral foramen showing in the radiogram. This foramen is normal, but the second one showing, the one through which runs the fourth cervical nerve, shows a ragged bony margin. In the recent state it is safe to say that the diseased tissue exceeded that shown by the roentgenogram. There is also shown a

FIG. 3

Showing practical obliteration of cervical foramen through which the fifth cervical nerve makes its exit.

certain amount of vertebral body and disc disease, allowing the bodies of the vertebrae to come closer together and still further reduce the diameter of the foramina. No muscular atrophy is present. The exact localization of subjective pain confined to shoulder, outer side of arm, forearm, and thumb pointed clearly to fourth, fifth, sixth, and seventh cervical nerve root involvement. The roentgenogram fully supported the diagnosis. Under treatment outlined later this patient obtained complete relief.

For the roentgenogram (Fig. 3) and for the privilege of reporting the following case I am greatly indebted to Dr. Lewis Gregory Cole. The patient, a male, 50 years of age, complained of severe pain about the right shoulder joint and outer side of arm. There was absence of shoulder joint disease. The radiograms gave the unique showing seen in the cut. I beg

to say here that in the reproduction from the X-ray photograph much of the delicate diseased tissue projecting into the foramen has been lost.

The foramen through which the fifth cervical nerve makes its exit was almost obliterated by new bone formation. This patient was operated upon. The foramen was gouged out, followed by complete relief of pain. The relief lasted six months, after which the pain returned. This meant probably that new bone had returned as it appears to do in similar pathologic bone conditions. It is questionable whether removal of bone in this type of disease will be ultimately successful.

Is New Bone Formation of the Spine, Producing Nerve Irritation, Rare? Some investigators hold that spinal root irritation due to disease pressure in arthritis is extremely rare. Neurologic surgeons are inclined to take this view. Some of these, however, have admitted to me that they have had little experience in the matter. The impression that the condition is rare appears largely due to the fact that operations are performed chiefly in cases giving cord symptoms. The cases we refer to are neuralgic, giving no cord symptoms and are rarely operated upon. The operative experience with these cases is at present negligible.

Treatment. Rational therapeutics, influenced largely by physiologic disclosures, has yielded the best results. A knowledge of what takes place in the joint teaches us to avoid traumata. The violent manipulations of the masseur do harm.

Faulty circulation is a potent factor in causing the disease to progress. Anything tending to improve the circulation allays the progress of the malady. Pemberton[1] has dwelt upon this factor of circulation, emphasizing reasons for regarding arthritis as influenced by certain phases of local or systemic oxidative metabolism, possibly involving the circulating fluid having to do with gas equilibrium of the blood. He calls attention to the fact that joints are structures whose blood supply is small, that in some tissues the blood flow can be diminished to a considerable degree without loss of oxygen, and that in others it can not. For full study of this very important point I refer you to Pemberton's article and to the studies of Pemberton, Hendrix and Crouter in collaboration with Dr. R. B. Osgood.[2]

All this teaches us the importance of aiming at restoring the circulation. This is to be done without trauma.

In order to accomplish this in cervical arthritis,—the type we are considering,—we adopt the following:

1. Daily exercise of head and neck, well known to you as carried out in the military colleges. This is of great value.

2. Backward movement of shoulders, also a military exercise.

3. Daily breathing exercises as used in the schools.

4. Slight rotary massage to upper part of spinal column to be given by the patient.

5. Slight suspension properly given is of great value. Many of you have observed a slight pressure paralysis in Pott's disease clear up temporarily under suspension, a slight removal of pressure having been sufficient to restore circulation. So here, slight suspension combined with the above mentioned list of mild exercises tends to remove a condition of stasis complicating the diseased tissues jutting out from the margins of the foramina. All this diseased tissue is not bone. If the progress of the disease can be stayed then we have right here a means of obtaining complete relief.

Believing that the intestinal tract is the chief feeder, if not the sole originator of this type of arthritis, treatment is instituted to the end of keeping the tract normal. We are not yet convinced of the value of "culture injections," and are doubtful if from their use we gain anything more than from proper use of the colonic irrigation.

Clinically, intestinal acid conditions form a factor. I have repeatedly observed exacerbations of this disease follow free daily use of grapefruit, cider, and other acids. The joints become painful and new swellings appear. We are taught in the physiologic laboratories that organic acids, such as citric and malic from eating fruit, become alkaline upon absorption into the blood and are beneficial in the disease we are considering. When absorbed, yes; but the etio-pathologic factor appears to take place in the intestine before the acid has been absorbed into the blood. Just how it acts injuriously in this place remains to be cleared up.

Patients afflicted with osteoarthritis tend to show a faulty elimination. Chemical blood examination in a large percentage of cases which have come under my observation gives a high uric acid content, 4 to 5 mg. in 100 c.c. of blood instead of the normal .5 to 2 mg. This argues for a diminished renal efficiency.

Recent studies show elimination of CO_2 through the perspiration, and Riffle and Barber[3] show excretion of acid to be a function of skin and kidney. Starling[4] states that at from 29 to 33 degrees Centigrade carbon dioxide output increases and at 34 degrees is doubled. The elimination of other acid substances through the skin has also been shown. This is contrary to former physiologic teaching.

The above explains in part the good results in these cases I have seen follow the daily hot bath given just before retiring. The hot bath is to be given just long enough to thoroughly start perspiration, and not to be

followed by cold. The skin is thus flushed and the internal organs are unloaded and favored in their work toward elimination.

Present Status of the Pathology of the Disease. We are getting nearer the solution of the etiologic problem. We feel sure enough of our ground to speak of it as the "passing" of the metabolic theory. Metabolic teaching is giving way to bacterial as it did in the proliferative type.

Nichols and Richardson's[5] findings in arthritis, which have passed into nearly every text book, still stand as a classic. Regarding the proliferative type there has been little change. The same does not so fully hold regarding the type under consideration, styled by them degenerative.

Recent studies tend to show that degeneration as a primary etiologic factor applied to cartilage cells must be discarded. Such studies show that the degeneration is confined to the ground substance while the cartilage cells tend to proliferate, which is difficult to reconcile with the theory of senile degeneration or diminished nutrition. Hoffa and Wollenberg[6] suggested that the changes might be due to deficient nutrition of the joint structure brought about by endarteritis obliterans of the nutrient vessels, but which recent work tends to disprove. The vessels and capillaries show no signs of obliterating endarteritis. The latter is found only in late stages of the malady.

Fisher, giving the results of his work to the Royal College of Surgeons, England, says: "The joint changes bear no constant relation to age. Similar pathologic appearances may occur in young individuals in whom the changes may be very marked." We all have seen very aged individuals showing no signs of osteoarthritis.

We find many signs pointing to an inflammatory process, or what pathologists regard as inflammatory. Even the cartilage which disappears shows this in early stages of the disease. The changes in the bone are first hyperplastic, not degenerative. The changes in the synovial membrane are hyperplastic, with marked increase of synovial villi, with formation of synovial chondromata, not degenerative. Fisher again says: "Arteriosclerotic changes may be seen in certain of the vessels of the synovial membrane, yet it is clear that these vascular changes advance *pari passu* with the changes in the membrane. It is also clear that they are not of etiologic importance, but are coincident, and like the changes in the membrane, inflammatory rather than degenerative." Nathan's[8] remarks on this subject are of interest here. He says: "It is useless, therefore, as I have pointed out before, to draw conclusions from specimens removed from aged persons, particularly in those cases in which the duration or the clinical history of the disease is unknown. Degenerative changes in such

cases may be, indeed nearly always are, simply the terminal stage of some inflammatory process."

To me it is clear that to dismiss this pathologic condition with the term "senility," as is frequently done, bespeaks a superficial knowledge indeed, nothing short of senile reasoning itself. Such a conclusion robs the patient of aid that modern medico-surgical skill should hold out to him. It points him to the gate over which stands the classical inscription, "Enter here, leave hope behind."

The findings, then, as we interpret them, supported by clinical and pathologic study, point to the work of some primary toxin with degeneration as one of the results. This is not unlike the degeneration occurring as one of the end-products of many well-known disease processes, and in no sense the primary lesion. The inflammatory findings are another factor. The combined action plus traumata give us the complete picture.

In the experimental production of osteoarthritis the important disease factor is lacking. Bruckhardt's[9] recent studies published in the Arch. f. klin. Chir., November, 1924, give us largely findings that have gone before. I wish to refer to the work of Allison *et al.* and to that of Nathan. Bruckhardt injected tincture of iodine into the joints of guinea pigs and rats. In some he permitted motion; in others obtained complete rest. Where motion was allowed there were findings later of injured cartilage, sclerosis of bone, formation of villi, occurrence of fibrosis, marginal proliferation; at rest, no changes. In larger animals he did not succeed in getting any showing.

He concluded from these findings that arthritis deformans is not a direct manifestation of disease, but represents a reaction of the tissues to an injury. The term arthritis deformans is used loosely in the text books and leads to confusion. But if he includes true osteoarthritis with its multiple bone deformities, as I infer he does, then he gives a part of the picture only, one with which we are all familiar, for we all recognize what continued trauma and changed joint mechanics can do to an already injured joint.

The attempt to initiate a true arthritis through injection of an organism or a toxin has so far failed. As an etiologic factor in the disease process the organism has lost its pus producing quality. It becomes the resultant of the original organism, attenuated, mutated, through elective localization—a variant or mutant of the original.[10] Witness how far experimental work must fall short of this.

I feel safe in saying that the experimental work done up to this time has given us very little beyond physiologic findings.

In true osteoarthritis, then, we are forced to the conclusion in accepting the impression that we have, first, the pathologic changes due to some toxin from a streptococcus or other organism; and second, added to this, findings that are purely physiological, in which the joint mechanics play a large part.

It has been said that the surgeon's share consists very largely in dealing by operation with failures of medical treatment.

Sir Robert Jones has frequently protested against the lack of co-operation between physicians and surgeons. Such co-operation is especially needed here. The surgeon might be spared the humiliation of being compelled to admit that the second state is worse than the first.

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DISCUSSION

Dr. Loring Swaim, Boston: There are one or two points which interest me. I had a man, an aviator, who fell from his machine during the war and fractured the lamina of the third cervical vertebra. I watched him for several years and he developed during that time a typical osteoarthritis at the point of injury. He was twenty-three years old. It seems to me a great many times the osteoarthritis is a reparative process of nature to prevent strain. That man had no other osteoarthritis in his body and he did have strain because of the curving forward of the body of the vertebra. I wonder if the common location of osteoarthritis in the spine and low back is not due to the fact that on these two areas, in our standing position, are placed the greatest strains. Likewise the occurrence of osteoarthritis in the hip-joint is undoubtedly due to strain. As we go through life nature forms this as a buttress to limit strain rather than as the result of an infective process.

Dr. M. N. Smith-Petersen, Boston: I would say that the hypertrophic changes are the result of strain, not a protective procedure, but a direct result of trauma. Dr. Swaim said nature protected the joint by these changes. These changes are in

relation to the ligamentous attachments around the joint rather than in relation to the joint itself.

DR. GEORGE R. ELLIOTT, New York City (closing the discussion): Dr. Swaim's explanation of why osteoarthritis selects the lower part of the cervical region for attack, as shown in my presentation to you, is probably the correct one.

I wish especially to re-emphasize the view I tried to bring out regarding the present status of the disease—that the inflammatory condition is becoming better understood and explains much heretofore in doubt. The bony outgrowths and the cartilage degeneration and the late period of life when this disease predominates have been too lightly dismissed in terms of senility and trauma.

I feel very safe in saying that the true pathology is now clearing up. We have here a true infection with a resultant inflammatory condition complicated by bony deposits, all very largely influenced by trauma.

EPIPHYSEAL COXA VARA OR DISPLACEMENT OF THE CAPITAL EPIPHYSIS OF THE FEMUR IN ADOLESCENCE*†

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INTRODUCTION

The head of the femur is so firmly fixed on the neck and the hip joint is so well protected by muscles and ligaments that traumatic separation of this epiphysis is unusual and for a long time was considered an impossibility. Poland[1] states that the first authentic case of traumatic separation of the upper epiphysis of the femur was that reported by Brousseau[2] in 1867. This was in a boy aged fifteen who was severely injured by the passage of the wheel of a heavy cart over the left hip. Death ensued within a few hours and post-mortem examination revealed a complete separation of the capital epiphysis of the femur. This case definitely established the possibility of the lesion, and from this time on an occasional specimen was recovered and a few cases were reported in the clinical literature. Poland in his extensive monograph published in 1898 was able to collect thirty-one cases from the literature. He ranks this epiphysis as being the third most frequent site of epiphyseal separation. In his book is to be found an adequate review of the subject up to 1898.

Epiphyseal or adolescent coxa vara of non-traumatic origin as a clinical entity is of still more recent date. Fiorani[3] in 1881 reported fifteen cases of adduction deformity of the hip in children. He regarded the deformity as a bending of the upper femur from localized rickets. His paper is inaccessible to me and in the abstract the cases are not described, but it is highly probable that some of them were epiphyseal coxa vara.

In 1886 Monks[4] reported a case of an unusual deformity of both hips in a boy of sixteen years of age. The typical history and characteristic physical findings in this case enable one to classify it as a case of bilateral epiphyseal coxa vara. Monks diagnosed the condition as arthritis deformans affecting both hips and causing softening of the bones with deformity from weight-bearing. His pathology was at fault, but sub-

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sequent years and a voluminous literature have added little to his clinical description of the condition.

In 1888 Keetley[5] reported a case in a girl of twenty years of age. He regarded the condition as adolescent rickets with a bending downward of the femoral neck. He corrected the adduction deformity by subtrochanteric osteotomy of the femur and myotomy of the adductors, thus being the first to institute this surgical procedure for the condition.

Muller[6] in 1888 reported four cases from Bruns' clinic. In one of these cases a resection of the head and neck of the femur was performed, the pre-operative diagnosis being tuberculosis of the hip. From the data obtained from the excised specimen and the study of the four cases, Muller introduced a new clinical entity into surgical literature. He termed the condition *Schenkelhalsverbiegungen im Jungesalter* or bending of the neck of the femur in adolescence, and is generally credited as being the discoverer of epiphyseal coxa vara. However, as will be pointed out later on in this paper, Muller's conception of the nature of the condition was erroneous.

Following Muller's report a number of the leading German surgeons became interested in the bending of the neck of the femur in early life. In 1894 Hofmeister[7] and Kocher[8] independently and almost simultaneously suggested the term coxa vara for the condition. The term became popular and was applied to various conditions in which an adduction deformity of the hip was present, and was assumed to be due to a bending downward of the neck of the femur. There was much controversy as to the cause of the bending in the idiopathic coxa vara of adolescence. In 1898 Sprengel,[9] on the basis of two resection preparations, showed conclusively that the clinical picture of adolescent coxa vara could result from traumatic separation of the capital epiphysis of the femur. He also showed that this separation could result from a relatively mild trauma. This, of course, added to the controversy. Joachimsthal[10] states that in 1898 twenty-two papers on coxa vara were published in the German literature alone. The subject coxa vara was prominent in surgical literature up to about 1912, and since that time relatively little has been written on the subject. General reviews of the subject are given by Zesas,[11] Drehmann,[12] Hofmeister,[13] de Quervain,[14] Perrin,[15] and Elmslie.[16]

DEFINITION AND CLASSIFICATION OF COXA VARA

As was stated above, the term coxa vara was proposed by Hofmeister and Kocher as a substitute for Muller's *Schenkelhalsverbiegungen im Jungesalter*. These two surgeons were, however, somewhat at variance

in their definition of coxa vara. Hofmeister[7] used the term to signify a skeletal deformity of the hip in which the angle of the neck with the shaft of the femur was diminished and the extremity maintained in a position of abnormal adduction. Kocher,[8] on the other hand, on the basis of a specimen which he obtained by excision, used the term coxa vara to describe a triple deformity of the neck of the femur. The neck was bowed upward, it was bowed forward, and it was twisted so that the distal extremity was hyperextended on the head of the femur. In Kocher's sense in coxa vara the limb must be in adduction, external rotation, and hyperextension. As the term came into more general use a wide variety of clinical conditions were described as coxa vara and it gradually was accepted in its anatomical sense (Alsberg[17]), and is now regarded as being synonymous with depression of the neck on the femur. This conception of coxa vara is a relic of old pre-roentgenologic days, when it was regarded as being due to a softening and bending of the neck of the femur. We now know that in the condition to which the term was first applied the femoral neck is not bent, but the deformity is due to a displacement of the epiphysis, and the relation of the neck with the shaft of the femur is for a long time unchanged. For this reason it is perhaps in order to define coxa vara as distinguished from an adduction deformity of the hip.

The term coxa vara should be limited to conditions in which the neck of the femur is intact and the head of the femur is in the acetabulum and not firmly ankylosed. In such a hip, when the extremity is maintained in a position of adduction or when the normal range of abduction is limited by bony deformity of the femur, coxa vara may be said to exist. The deformity may be in the head, epiphyseal line, neck, or trochanteric region of the femur.

As the term coxa vara became accepted in its anatomic sense clinical classifications were in order. The most widely accepted are those of Alsberg,[18] Helbing,[19] Hofmeister,[13] and Drehmann.[20] All are based on etiology. Now that the X-ray is so generally available it is possible to classify our cases anatomically as well as etiologically.

Such a classification is the following:

A. Capital Coxa Vara.

1. Legg-Calvé-Perthes disease (osteochondritis juvenilis), (coxa plana).
2. Arthritis (hypertrophic, atrophic, or malum coxae senilis).
3. Destructive disease (tuberculosis, pyogenic, Charcot's disease, etc.).

B. Epiphyseal Coxa Vara.
   1. Idiopathic.
   2. Traumatic.

C. Cervical Coxa Vara.
   1. Congenital deformity.
   2. Congenital deformity in old reduced congenital dislocation.
   3. Developmental or constitutional disease (rickets, achondroplasia, osteopsathyrosis, cretinism, osteogenesis imperfecta, osteitis deformans, osteomalacia, etc.).
   4. Destructive disease (tuberculosis, osteomyelitis, syphilis, neoplasms, cysts, osteoporosis, osteitis fibrosa, etc.).
   5. Fracture with malunion.

D. Trochanteric Coxa Vara.
   1. Destructive disease as in C.
   2. Fracture with malunion.

In the above classification coxa vara is used purely in the anatomic sense. When used as a diagnosis the term coxa vara should be preceded by the adjective locating the chief deformity and followed by the etiology, as: cervical coxa vara due to rickets; or, trochanteric coxa vara due to old osteomyelitis, etc.

INCIDENCE

Epiphyseal coxa vara is not a common condition, yet it is probably the most frequent cause of disability in the hip, which begins in the adolescent period. I was able to obtain data upon twenty-four cases which were seen at the Massachusetts General Hospital during a period of eighteen years (August 10, 1904 to January 28, 1922, inclusive). It is these cases which form the basis for this study of the condition. The cases were reviewed by me in 1921 and 1922 while working in the orthopaedic clinic. At that time Dr. Osgood was chief of the service and I am indebted to him not only for permission to study the material, but also for encouragement and stimulation to complete this analysis of the present status of the condition.

In Table I is given a summary of our cases. It is noticeable that epiphyseal coxa vara is being seen more frequently at the Massachusetts General Hospital in recent years. This is probably because we are recognizing the condition when it is presented to us. A fair average in a large

orthopaedic clinic is from two to five cases of epiphyseal coxa vara a year.

From the literature it is difficult to judge how frequently the condition actually occurs. Schanz,[21] in an analysis of one thousand private orthopaedic cases, encountered twelve cases of coxa vara. Among one thousand orthopaedic cases in Steindler's[22] clinic epiphyseal coxa vara occurred ten times. Whitman[23] in 1919 had seen seventy-two cases of coxa vara, and forty of these occurred in adolescents. Kleinfelter[24] remarked that he had seen nine cases in a year's time. Helbing[19] reports seventy-seven cases of coxa vara from Hoffa's clinic. Only twenty of these cases were of the epiphyseal type and they occurred among ten thousand orthopaedic cases. Hofmeister[25] in Bruns' clinic encountered forty-five cases of coxa vara in a period of three years (1894–97). During this time twenty-one thousand cases (probably all types of surgery) passed through the clinic. In a period of ten years Hofmeister had seen eighty cases of coxa vara. Of the first forty, thirty-two were of the epiphyseal type. In Bruns' clinic he noted twenty-two cases of coxa vara to forty-seven cases of genu valgum.

If we compare epiphyseal coxa vara with tuberculosis of the hip, the former is much less common. Hofmeister noted twenty-two cases of coxa vara to three hundred and ninety cases of tuberculosis of the hip. But less than ten per cent. of the cases of tuberculosis of the hip begin during adolescence. Whitman[23] in one thousand cases of tuberculosis of the hip found ninety-five cases in which the disease began between the eleventh and nineteenth years of life. As bone tuberculosis seems to be steadily decreasing epiphyseal coxa vara is at present probably a more frequent cause of lameness in the hip beginning in adolescence than is tuberculosis. The condition occurs more often in males. In our series there were seventeen males and seven females. In a series of two hundred and fifty cases reported in the literature by various surgeons there are one hundred and ninety-two males to fifty-eight females. For reasons pointed out in a previous paper (Key[26]) the condition is limited to adolescent life. In Table I it is seen that in our series the youngest patient was ten years of age and the oldest patient was seventeen years of age when the epiphyseal coxa vara began. It is to be remarked that it tends to begin earlier in the female. In our series the average age at onset in six girls was 11.3 years and in seventeen boys it was 14.3 years. In the cases from the literature the ages given varied from nine to nineteen years; and the average for the girls was 13.5 years and the average for the boys was 15.4 years. Not infrequently the condition is bilateral. In our

TABLE I

	Initials	Sex	Age at Onset	Duration of Symptoms	Constitutional Type	Side Affected	Shortening in Inches	Onset	Condition on Admission	Treatment	Admitted	Last Treated	Last Note
1	W. R.	M	15	2 months	Normal	R		Gradual	Hip flexed and everted. No motion permitted.	Traction and spica 5 months.	8–10–04	10–17–05	½ inch shortening. Walks with marked limp. Some pain. Motion good. (?)
2	H. G.	F	12	3 years	Normal	R	1	Trauma	Hip flexed, adducted, and everted. Not painful.	Intertrochanteric osteotomy. Spica 20 months.	12–1–08	1–29–15	Lame since operation. ¾ inch shortening. Motion limited.
3	J. W. A.	M	12	1½–2½ yrs.	Normal	R–L	¾	Gradual Gradual	No pain. Flex. 30, Abd. limit. Int. R. limited. No pain. Flex. 75, Abd. 10. Int. R. 0.	Subtrochanteric osteotomy. Right wound infected.	5–7–09	5–30–09	Secondary hemorrhage and death.
4	B. C.	F	11	10 months	Fat	L	1¼	Trauma	Hip everted. Flex. to 90, Abd. 10.	Obesity diet, curved osteotomy. Spica 2 months. Crutches.	10–12–09	5–27–11	No pain. ¾ inch shortening. Hyperextension and Int. Rot. limited. Flex. to 90°, Abd. to 10°.
5	G. W.	M	14	2 months	Normal	R	½	Trauma	Flex. to 45, Abd. and Int. R. limited.	Manipulated. Spica 2 months. Crutches.	11–4–09	9–25–19	No pain, deformity, shortening, or limitation of motion.
6	R.T.M.	M	15	2 months	Feminine	R	¾	Trauma	Abd. 20, Int. R. 0. Flex. limited.	Manipulated. Spica 2 months. Crutches.	10–9–11	2–29–12	Hip stiff. No pain. 1 inch shortening. Flex. 115°, Abd. 25°, Int. Rot. 0°.
7	M.A.M.	F	13	5 months	Normal	R	1	Trauma	Acute pain. Fixed in Flex. 30, Abd. 20, and Ext. R. 30.	Manipulated. Spica 4½ months.	3–21–17	1–5–20	No pain. Hip practically ankylosed in 30° Flex. and 20° Add. 1 inch short.
8	V. R.	F	12	16 months	Fat	L	1	Gradual	Acute hip adducted and Ext. R. Flex. 90.	Obesity diet and pituitary extract. Manip. twice. Spica 11 months.	10–8–17	1–30–19	No pain. Flex. 90°, Int. Rot. 0°, Abd. 15°, Ext. Rot. 35°. 1 inch short.
9	N. T.	M	12	1 year	Slight Rachitis	L	2	Gradual	Abd. 20 and Int. R. limited.	Manip. twice. Spica 6 months.	3–26–19	10–26–19	In Spica. Did not return. Last ½ inch short.
10	F. R.	M	16	6 months	Slender Normal	L	½	Gradual	Acute epiph. sep. Hip extended, Add. and Ext. R.	Manip. unsuccessfully then open replacement of epiph.	12–1–21	4–15–22	Wilson's Case I.
11	M. C.	F	10	3 years	Slight Obese	L	1	Gradual	Acute hip. Flex. 25, Add. 20, and Ext. R.	Spica 8 months.	10–23–18	4–11–21	Flex. to 65°, Abd. 15°, Int. Rot. 0°. 1 inch short.
12	S. L.	M	14	1 year	Normal	L	1½	Sudden	Flex. 90, Abd. 0, Int. R. 5.	Spica 6 weeks. Brace 8 months.	3–13–20	1–28–22	Flex. 75°, Abd. 10°, Int. Rot. 0°. 1½ inch short.
13	E. B. C.	M	16	3 years	Normal	L	1	Gradual	Flex. 55, Abd. 10, Int. R. 0.	Operation refused. Corrective only.	3–28–21	4–28–22	Perm. Flex. 20°, Flex. to 85°, Int. Rot. 0°. ¾ inch short.

14	G. B.	M	14	2 months	Normal	L	½	Trauma	Flex. 60, Abd. 0, Int. R. 0.	Spica 4 months. Corrective exercises 1 year.	1-29-21	4-11-22	Flex. 40°, Abd. 30°, Ad. 15°, Int. Rot. 0°. ½ inch short.
15	T. J. D.	M	12	33 years	Normal	L	1	Trauma	Abd. and Int. R. limited.	Exostosis on grt. trochanter removed. Crutches 1 month.	4-4-11	8-9-21	Occasional pain. Flex. 130°, Abd. 0°, Int. Rot. 0°, Perm. Flex 15°. ¾ inch short.
16	S. R.	F	?	?	Normal	R	¾	?	Pain in right hip.	Rest and ½ inch lift on left heel.		1-28-22	Mod. pain. Flex. 80°, Abd. 30°, Int. Rot. 0°. ½ inch short.
17	F. K.	M	15	4 months	Normal	R L	1	Gradual Gradual	Abd. Flex. and Int. R. limited.	Operation and bone removed from ant. part. Spica 1 month.	11-15-06	4-26-22	Rt. Flex. 45°, Abd. 0°, Int. Rot. 15°. 1 inch short. L. Flex. 135°, Abd. 20°, Int. Rot. 25°.
18	K. M.	F	10	2 years	Fat	R	1	Trauma	Flex. 90, Abd. 15, Int. R. 0.	Manip. Spica 5 months. Brace 6 years.	4-15-12	4-12-21	In splint. No motion. Flex. 20°, Abd. 0°, Int. Rot. 0°. 1 inch short in hip. Neurotic.
19	A. F.	M	13	9 months	Fat	R-L		Gradual	Flex. 0, Abd. 10, Int. R. 0. Flex. normal, Abd. normal, Int. R. 15.	Obesity diet and pituitrin. Manip. Spica 7 months.	7-24-16	3-22-22	Rt. Flex. 30°, Abd. 10°, Int. Rot. 10°. L. Flex. 120°, Abd. 25°, Int. Rot. 0°.
20	J. B.	M	16	6 months	Normal	L	½	Gradual	Flex. 60, Abd. 20, Int. R. 0.	Manipulated. Spica 9 months.	10-18-18	2-13-22	Flex. 90°, Abd. 5°, Int. Rot. 0°. ½ inch short.
21	H. C.	M	15	1 year	Adolescent	R-L	½	Gradual	Flex. 90, Abd. 20, Int. R. 0. Flex. 45, Abd. 20, Int. R. 0.	Manipulated. Spica 2 months. Brace 8 months.	3-7-21	3-30-22	Rt. Flex. 60°, Abd. 5°, Int. Rot. 10°. L. Flex. 15°, Abd. 15°, Int. Rot. 20°. ½ inch short.
22	J. E. C.	M	17	9 months	Slender Normal	L	5/8	Trauma	Acute hip add. Ext. rot. in 45 Flex.	Manipulated. Spica 4 months.	11-15-19	3-27-22	Perm. Flex. 15°, Flex. 20°, Abd. 10°. Int. Rot. 0°. 1 inch short.
23	M. K.	M	13	1 year	Normal	L	¾	Gradual	Acute hip. Flex. to 50. Abd. to 20. Int. R. limited.	Manipulated. Spica 1 month. Brace 5 months.	10-4-19	9-12-21	Flex. 50°, Abd. 10°, Int. Rot. 0°. 1½ inch short.
24	F. A. D.	M	13	10 months	Normal	L	¾	Gradual	Flex. 45, Abd. 5, Int. R. 0.	Manipulated. Spica 2 months. Crutches.	5-6-21	3-6-22	Flex. 120°, Abd. 10°, Int. Rot. 5°. 1 inch short.

I. Summary of cases of epiphyseal coxa vara from the Massachusetts General Hospital.

series of twenty-four cases four were bilateral. Hofmeister found one-third of his cases to be bilateral. In the cases in the literature thirty-eight, or 15.2 per cent., were bilateral. The left hip is affected more frequently than the right. In our series the ratio is seventeen left to fourteen right hips. Manz[27] found forty-eight left to twenty right hips affected. In one hundred unilateral cases from the literature there were sixty-three left and thirty-seven right hips affected.

CLINICAL PICTURES

The histories of any large group of cases of epiphyseal coxa vara can be roughly divided into two classes: non-traumatic and traumatic. In the non-traumatic or so-called idiopathic type there is nearly always a history of pain. The pain may be confined to the hip, but usually radiates to the lower thigh and knee. In one of our cases the patient's only complaint was a limp and pain at the inner side of the knee, and the first impression was that this patient had a strain of the internal lateral ligament of the knee. In some instances the pain is referred to the leg or foot, and in other cases it is felt in the groin.

As a rule the pain is not severe in character and it is not constantly present. A very common history is that some months previously the patient began to tire easily and that after walking or standing more than usual he had some pain in one or more of the regions mentioned above. This condition existed for a few days or weeks and then disappeared for a short time, only to reappear and become somewhat more severe in character. By the time the patient consulted a physician there may have been several such attacks. In the early stages the pain is always relieved by rest and the patient is not troubled at night unless perchance he lies for some time on the affected side, when a dull ache may develop in the hip or extremity. The pain is accompanied by a limp which is noted by the parents. As the condition progresses the limp persists even when the pain is not present. The patient may have noted that the affected extremity was becoming shorter and smaller than that of the unaffected side. He may also state that the limb tends to turn outward, is restricted in movements at the hip, and is weaker than normal. In rare instances such as that of Whitman[28] and our Case 19, there may be absolutely no history of pain. On the other hand, when first seen by the physician the patient may be bedridden by severe pain in the hip which is accentuated by the least movement. As a rule there is no history of any preceding or accompanying illness or constitutional disturbance.

Both hips may be affected. In the bilateral cases there is usually an interval of some months after the beginning of the trouble before the onset of symptoms in the second hip.

The above is what might be termed a pure non-traumatic history. More frequently the patient ascribes his trouble to some injury. He may have had a slight fall or received a blow upon the hip, or the trauma may have been severe. As a rule, however, the injury which the patient regards as the cause of his difficulty is a rather trivial one and not of sufficient severity to cause serious trouble in the hip of the average normal adolescent. In many of these so-called traumatic cases the physician can by questioning elicit the fact that the patient had had some mild pain in the hip before the injury occurred, and that the accident only served to enhance a pre-existing condition.

The immediate effect of the trauma varies in different cases. In some cases after a fall on the hip there is a dull ache with very little disability, while in others a similar fall may result in severe pain and immediate total inability to use the affected extremity. There is no relation between the severity of the injury and the extent of the disability. In some instances one obtains a history of series of minor accidents, each followed by a period of pain and disability from which the patient recovered. In cases of this type the recovery from each trauma is apt to be more slow and less complete than was the recovery from the preceding one.

An occasional case of epiphyseal separation is seen in which there was a violent injury quite severe enough to cause a fracture of the neck of the femur in a normal person. The history is that of a fracture of the femur. All gradations exist between this type and the non-traumatic cases with gradual onset.

Just as there is a wide variation in the subjective symptoms, so is there wide variation in the objective findings. As the condition tends to continue active over a period varying from one to three years, the physical findings naturally vary considerably at the different stages of the process. One patient when examined may present a hip with little or no abnormality in appearance or measurements, while in another patient the hip is markedly deformed with considerable atrophy and definite shortening of the extremity. In either of the above cases the hip may be painless and freely movable within the range permitted by the deformity, or exquisitely sensitive and fixed by muscle spasm.

As will be noted in the discussion of the etiology, there is an abnormal condition present in the femur before the epiphysis is displaced. Theo-

retically, in the cases with gradual onset there is nearly always some pain before there is any atrophy or displacement of the epiphysis. Dr. Osgood[29] made the diagnosis in one instance before any displacement of the epiphysis had occurred. The patient, an obese girl of fourteen years, stubbed her toe in leaving his office and abruptly slipped the epiphysis. The diagnosis was made on the persistent mild pain in the hip, accentuated by standing and relieved by rest, occurring in an obese adolescent. The physical examination showed a slightly sensitive hip with some pain on abduction and internal rotation. The roentgenogram showed a slight broadening of the epiphyseal line and nothing else abnormal. Vieullet's[30] Case 1 is a similar instance and Schanz[31] reported five cases of early coxa vara, only two of which, however, were definitely of the epiphyseal type.

Opportunity to make an early diagnosis in epiphyseal coxa vara is unusual, as these cases do not as a rule seek medical attention until after the condition has been going on for some time and the deformity is definitely established. In our series (Table I) the duration of symptoms is recorded. It is seen that the earliest case entered the clinic two months after the onset of symptoms. There were four such cases and all gave a history of trauma. Excluding the two adult cases (Nos. 15 and 16) the average duration of symptoms in our twenty-two cases was 14.6 months when they entered the clinic.

The typical unilateral case, then, as seen by us is a patient with the deformity well developed and not in the extremely acute stage. The patient walks with a slight limp in which the body sways to the affected side, and there is a tendency for the pelvis to sag on the unaffected side when the weight is borne upon the affected extremity (positive Trendelenberg). Walking may or may not be painful. The patient stands with the affected leg rotated outward and slightly adducted (Fig. 1). The normal lumbar lordosis may be decreased, increased, or unaffected (Fig. 1).

On inspection from behind, with the patient in the erect posture (Fig. 1), it is seen that the pelvis is tilted laterally, being slightly lower on the affected side. There is a slight spinal scoliosis with the lumbar curve towards the affected side and the dorsal curve towards the sound side. There may be some permanent rotation of the vertebrae with prominence of the ribs posteriorly on the sound side when the patient bends forward. There appears to be some atrophy of the buttock on the affected side, a definite depression being visible posterior to the trochanter, and the gluteal fold being lower than on the normal side. Viewed from the front the trochanter on the affected side is unusually prominent and

there may be a visible fullness in the groin on that side. There is a moderate atrophy of the thigh (one-half to two inches) and there may be slight atrophy of the calf on the affected side. Genu valgum may or may not be present and the feet may or may not be pronated. On palpation a hard mass can often be felt in the groin on the affected side. This moves with the femur, and from its location seems to be the thickened

FIG. 1

Epiphyseal coxa vara (left) one year after onset following fall from a horse. (Shriner Hospital Case.)

head and neck of the femur. The buttock is flabby and the fingers sink into the depression behind the trochanter. The hip is as a rule not tender, but pressure upon the trochanter or heel may cause dull pain in the hip. The trochanter is higher than on the sound side and its tip is above the Roser-Nélaton line (usually about one-half to one inch). If measured from the mid-line of the body the trochanter on the affected side is often slightly farther from the mid-line than is that of the sound side (one-quarter to three-quarters inch). The affected extremity is

shorter than that on the normal side. The shortening, measured from the anterior superior spine to the internal malleolus, is one-half to one and one-half inches (usually about three-quarters inch). This shortening is found to be in the femur.

On manipulation one finds more or less limitation of motion in the affected hip. In my experience the hip has always assumed a position of external rotation and slight adduction when the patient lies on the back. (I have not seen cases as described by Hofmeister[7] in which the hip was either in the neutral position or internally rotated.) The hip is extended, but if the unaffected thigh be fully flexed upon the chest, thus flattening the lumbar spine, there is often fifteen or more degrees of permanent flexion to be detected in the affected hip (Fig. 2). Flexion of the affected hip is almost always limited, usually to about eighty to ninety degrees. A very characteristic finding is that as the hip is flexed it passively rotates outward, so that with ninety degrees of flexion the hip is usually permanently rotated outward about forty-five degrees. Adduction is as a rule free, being limited only by the soft parts. Abduction is markedly limited; as a rule not more than ten or fifteen degrees is obtainable. In some cases there is permanent adduction with functional shortening. Rotation is best measured by turning the patient upon the face and having an assistant fix the pelvis. The knees are flexed and the legs serve as guides for determining the amount of motion in the hips. Internal rotation is determined by pushing the feet apart, thus rolling the femora outward from behind, and external rotation by crossing the legs and rolling the femora inward. In the affected hip external rotation is usually more free than normal (sixty to seventy degrees being not uncommon). Internal rotation is always sharply limited, usually only ten to fifteen degrees being obtainable, and there is often some permanent external rotation. Hyperextension of the affected thigh with the patient in the prone posture is usually limited on the affected side.

A rather characteristic point about these subacute or quiescent cases is that the ranges of active and passive motion are about equal. Furthermore, if the patient be examined while anaesthetized the limitations of motion are found to be unchanged.

As Hofmeister[13] pointed out, most cases of epiphyseal coxa vara at some stage of the process enter an acute phase. At this time the hip is exquisitely painful and is fixed in external rotation and adduction by muscle spasm. Little or no movement is obtainable. If such a patient be anaesthetized and then examined with the muscles relaxed the motions of the hip are found to be similar to those described above, or a few days

of rest in bed may attain the same result, especially if extension be applied to the extremity.

A somewhat different picture is that of the recent acutely separated epiphysis. These cases resemble a fresh fracture of the neck of the femur. The position of the limb is as described above and there is the tenderness and swelling as in any other fresh fracture. Some authors have described a soft crepitus as being obtainable in these cases.

In bilateral cases the gait is an awkward, rolling one, with the body swaying from side to side at each step as in a bilateral congenital dislocation of the hip. The examination of the hips is as given above except that both sides are affected, usually unequally, and there is no normal for

FIG. 2

Epiphyseal coxa vara (right). Duration two years. Permanent Flexion 35° on entrance. (Shriner Hospital Case.)

comparison. These patients are not sick, and the general physical examination is negative except for the frequent occurrence of certain constitutional types, as will be mentioned when the etiology is discussed. Laboratory examinations are negative. Blood counts are normal, the Wassermann is nearly always negative, the tuberculin test may be negative, and the urine is normal. In two of our cases sugar tolerance tests gave normal results. In recent cases at the Massachusetts General Hospital the calcium and phosphorus contents of the blood were normal or slightly increased (Wilson[32]).

ROENTGENOGRAMS

Not only is epiphyseal coxa vara a progressive condition extending over a period of from one to three years, but after the migration of the epiphysis has ceased the process of adjustment sets in and lasts until

early adult life when growth is completed. Furthermore, during the active stage a slight trauma may cause an abrupt separation of the epiphysis with consequent modifications in the X-ray picture. Under these conditions one is justified in describing six main types of roentgenograms as occurring in epiphyseal coxa vara:

1. Before any displacement of the epiphysis has occurred the hip is essentially normal in appearance. The only abnormality visible in the roentgenogram is a questionable broadening and irregularity of the epiphyseal line.

2. *Early non-traumatic type.* There may be slight rarefaction in the head and in the region of the neck adjacent to the epiphyseal line, but as a rule the bone structure of the femur and the pelvis is normal. The contour of the acetabulum is normal and there is no evidence of any arthritic change in the hip. The joint space is clear and of normal width, there being no evidence of destruction of articular cartilage. The head of the femur is in the acetabulum, but is rotated so that its lower and posterior borders are displaced outward. The head is thinned out and appears to be enlarged in the vertical axis. The thinning of the head is most marked in its upper half. In the roentgenogram the shadow of the head is crescent- or sickle-shaped. Not only is the head changed in contour, but it is displaced slightly on the neck. The lower border of the head projects slightly as a beak-like process, extending down beyond the line of the lower margin of the neck. The upper margin of the head is thinned out and is a short distance from the prominence on the upper border of the neck near the epiphyseal line.

The epiphyseal line is not visible above the upper border of the head. Where the head is in contact with the neck it is vague, irregular, broadened, and almost vertical in direction. The femoral neck is normal in its relation to the shaft of the femur, but its upper border is lengthened and roughly convex upward, while its lower border is shortened and appears to be more sharply curved upward than is normal. The upper border of the neck is really more angulated than curved upward, and the apex of the angle is the prominence referred to above which marks the mesial end of the true upper border of the neck. The lengthening is due to the displacement of the head, leaving bare the upper portion of the mesial extremity of the neck, which is flattened and inclined downward and inward. The lower border of the neck is buried in the concave epiphyseal surface of the head and thus apparently shortened. Between the lower border of the neck and the overhanging lower margin of the head some new bone formation is to be seen.

3. *Advanced non-traumatic type.* The femoral head is markedly displaced and rotated so that only its upper and anterior half is in the acetabulum. Its articular surface is directed inward, backward, and downward. The projecting lower border of the head curls outward and upward to approach the lower border of the neck. From this point the posterior border of the head can be traced curving upward and inward across the neck to approach the thin upper border of the head. The epiphyseal line is absent above and broad and irregular below where the head is in contact with the neck. It is inclined downward and outward.

The neck is often thickened and its elongated upper border is less angular, though the prominence referred to above is definitely present. Its inner portion is smooth and rounded and is in contact with the acetabulum. The lower border of the neck is sharply bowed upward and markedly shortened. The angle of the neck with the shaft appears to be decreased to about ninety degrees, and the whole neck is apparently bowed upward, the apex of the curve being the prominence marking the original mesial extremity of the upper border. The acetabulum is enlarged in the vertical diameter and the pelvis is slightly deformed on the affected side, the ischium being bent inward as in the ischium varum of Murk Jansen. There is definite alteration of the bone structure of the femur. The head is moderately atrophic, especially in its projecting lower half. There is some rarefaction in the upper portion of the neck and the dense lower border (Adam's bow) is thicker than normal. The joint space is clear and there is no evidence of arthritis.

4. *Early traumatic type.* The head is separated from the neck and lies in the acetabulum. It is rotated obliquely so that its lower and posterior borders are out of the acetabulum and applied to the neck of the femur. The head is normal in contour and its articular surface is directed downward, inward, and backward. The femur is displaced upward and externally rotated, the upper border of the neck being in contact with the acetabulum and the lower border is embedded in the cancellous tissue of the epiphyseal surface of the head. The neck points upward, inward, and forward. There is no bone atrophy. The joint line is apt to be rather hazy from the extravasated blood. Except for the displacement of the head upon the neck, the contour of all the bones is normal.

5. *Late traumatic type* (Fig. 3). The head is firmly fixed in its new position on the neck by callus and new bone. As time goes on the upper border of the mesial extremity of the neck is rounded off, and with the upper and anterior part of the head enters the acetabulum to form the hip joint. The condition resembles the late non-traumatic

epiphyseal coxa vara described above. The only difference between them is that in the traumatic type the head becomes markedly atrophic but retains its normal contour for several years.

6. In adult life the idiopathic and traumatic types are indistinguishable. The epiphyseal line has disappeared and the head and neck appear

FIG. 3

Roentgenogram of hip of case shown in Fig. 1.

as a solid mass of bone. The neck may appear elongated and bowed upward with the lower border of the head projecting below as in the left hip of Figure 23. More frequently the neck is thickened and shortened as in the right hip of Figure 23 and in Figures 24 and 25. In this type with the enlarged mushroomed head the radiogram of the hip in adult life resembles that of an old Legg's disease (Fig. 24). The acetabu-

lum is enlarged to accommodate the head of the femur, and in later life arthritic changes develop in the hip (Fig. 25).

In the above description six types of roentgenograms have been mentioned as occurring in epiphyseal coxa vara. It is to be emphasized that this division is purely arbitrary and is made for the purpose of description. There are only two types of epiphyseal coxa vara, namely: the traumatic and the non-traumatic. The roentgenograms of these in the early stages are characteristic. Later, as the condition progresses, they gradually come to resemble one another more and more closely, until in the adult it is impossible to determine from the roentgenograms whether the original condition was traumatic or of gradual onset.

It is also to be noted that all transitions between the early and late stages of each type occur. Furthermore, a non-traumatic type may by trauma be converted into an atypical traumatic type.

PATHOLOGY

Our knowledge of the pathology of epiphyseal coxa vara is still inadequate to explain the condition. In the earlier cases an excision of the hip was not infrequently performed in an effort to better the patient's condition. A number of these excised heads and necks were studied and the findings reported. The surgeons reporting them and the number of specimens by each are: Muller (1), Kocher (3), Hofmeister (2), Sprengel (2), Haedke (1), Schlesinger (1), Maydl (2), Helbing (1), Frangenheim (6), Rammstedt (4), Kappis (1), and Grashey described a specimen recovered at a post-mortem examination.

Muller's[6] specimen is described as a simple bending downward of the neck of the femur. The upper border of the neck was about twice the normal length and the lower border was only 1.5 cm. long and sharply curved. The articular cartilage was normal. On section the epiphyseal line was visible as a narrow strip, but no cartilage was present. The epiphysis was sickle-shaped and capped the diaphysis as though the diaphysis had been driven into the epiphysis by a wedge fracture. The internal architecture of the bone was markedly changed. Adam's bow was thickened (1.5 cm.), and the compact bone extended along the lower border of the neck to the epiphyseal line. The bony lamellae were heavy in the upper and inner part of the neck and thin in the lower and inner part. Microscopic preparations were studied by Ziegler and showed normal bone and marrow. The cartilage of the epiphyseal line was normal but in the adjacent bone the osteoblasts and osteoclasts were more numerous than normal.

Kocher[8] excised three hips in two patients with epiphyseal coxa vara, one of the cases being bilateral. His gross findings differ from those of Muller in that the neck was bent obliquely downward and backward. There was also a torsion of the neck which was especially marked in one case, the head being rotated upon the neck in such a manner that with the head in its normal relationships, the femur was hyperextended. On the part of the head not in contact with the acetabulum the cartilage was atrophic, and in one instance was ravelled and covered with a thin pannus. Microscopic studies made by Langhans showed widening of the marrow spaces with hyperemia and abundance of marrow and fat cells, and a paucity of osteoblasts and osteoclasts. Areas of calcium free osteoid tissue and lattice figures of von Recklinghausen were present in the bony lamellae in one case and suggested a diagnosis of juvenile osteomalacia.

FIG. 4

Right hip of Kocher's Case 1, anterior and posterior view. Duration one year.

The epiphyseal line was irregular, the cartilage being interrupted by ingrowing spongiosa (Fig. 4).

In Haedke's[33] specimen the articular cartilage was thinned in places with dark spongiosa shining through. The epiphyseal line was very irregular in its upper portion but well formed below. It was broken here and there by dark red young bone. In the upper part of the neck, even under the periosteum, were irregular sized islets of cartilage. The zone of cartilage was broadened. Considerable osteoid tissue was present. Areas of fibrous tissue in the marrow merged into the osteoid tissue of the lamellae. Hofmeister's[7] first specimen was a necrotic head removed from a case which became infected after an osteotomy of the neck. The roentgenogram of the specimen showed a crescent-like head. His second case was a traumatic case of one and one-half years' duration. The roentgenogram showed a head markedly thinned in its lower half.

Both of Sprengel's[9] cases were of traumatic type and fairly recent. In the first case the head was only partially separated and in the second

case it was completely displaced and lay with its epiphyseal border parallel with the lower border of the neck. In both cases the head was essentially normal in contour. The specimens (studied by Beneke) showed callus and fibrous tissue binding the head to the neck. Necrotic bits of bone and cartilage and extravasated blood were found in this area. The diagnosis was traumatic separation of the epiphysis with union by callus and fibrous tissue (Fig. 5).

Helbing's[19] specimen in the roentgenogram resembled the second type of Hofmeister.[13] The epiphyseal line was broad and irregular. On

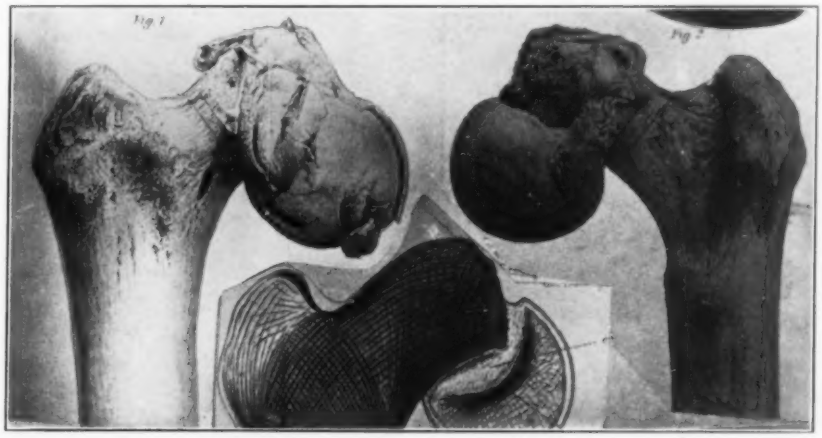

FIG. 5

Left hip of Sprengel's Case 1. Anterior and posterior view and drawing of section. Duration three months. (Traumatic.)

microscopic examination the epiphyseal line was broken by bone and osteoid tissue. The columns of cartilage cells were absent and there was no longer any regularity in the arrangement of the cartilage cells. Extravasated blood and fibrous tissue were present in the marrow. Large numbers of cartilage cells were present in the joint capsule.

The case of Hoffa, reported by Schultz[34] and so often quoted as the second specimen described, was definitely of the congenital type and need not be considered here. The two specimens of Maydl[35] resembled those of Kocher. He compared them with specimens of arthritis deformans juvenilis. The specimens reported by Rammstedt[36] were regarded by him as traumatic separation of the epiphysis. They resembled Sprengel's

specimens. All showed posterior and downward displacement of the head with the epiphyseal line broken by long trabeculae of bone. The head was bound to the neck in some areas by fibrous connective tissue.

Schlesinger's[37] specimen resembled Kocher's classical specimen with the marked torsion of the neck in addition to the usual displacement of the head. The cartilage on the upper part of the head was normal, but

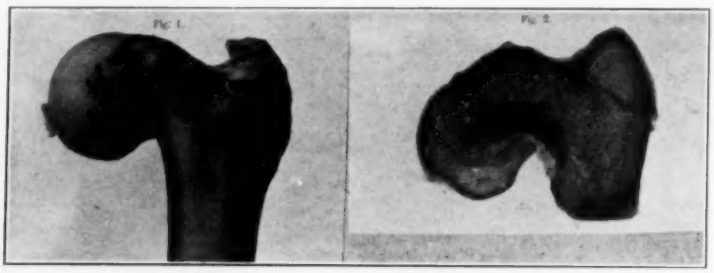

FIG. 6

Schlesinger's preparation. Anterior view and section. Duration four months. (Traumatic.)

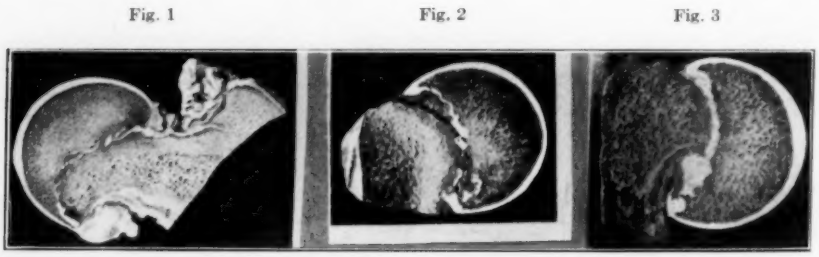

FIG. 7

Frangenheim's three specimens reported in his second paper. Duration: No. 1, two months; No. 2, six months; No. 3, six weeks. No. 1 followed a fall on the hip.

on the lower part was thin and brittle and in the microscopic sections studied by Benda not a single normal cartilage cell was seen in this region. The epiphyseal line was 0.5 cm. broad and the arrangement of the cartilage was irregular with small islets of cartilage and necrotic cells and nuclei scattered here and there. The lower part of the head showed marked bone atrophy, but Adam's bow was thickened and here the bone was very hard (Fig. 6).

Frangenheim[38, 39] studied six resection preparations which exhibited varying degrees of displacement of the head. Microscopically, the cartilage of the epiphyseal region was more cellular than normal and the cells were irregular in their distribution. The cartilage was vascular, and enchondral ossifications in various stages were present in the netlike cartilage matrix. Cartilage islets of varying size were seen in the neighboring marrow tissue. In one case the head was bound to the under surface of the neck by connective tissue in which extravasated blood lay between the fibres. In this head were sclerotic bone lamellae with empty lacunae (Fig. 7).

In the specimen reported by Kappis[40] the head was bound to the neck by callus. The callus showed irregular fibrosis and hyaline cartilage with much connective tissue covering the surface of the neck and encroaching upon the articular cartilage as a pannus. The cells of the epiphyseal and articular cartilage were living, but the bone of the head was entirely necrotic and the marrow was necrotic in many places. New bone was being formed to replace the necrotic bone of the head.

Grashey[41] obtained a post-mortem specimen from a patient who died of peritonitis. The right hip showed the typical deformity well advanced, and the left hip showed a slight deformity of the head and bluish coloration of the articular cartilage. The pelvis was asymmetrical (ischium varum of Murk Jansen or oblique coxalgic pelvis of Hofmeister).

There are then at least twenty-four pathologic specimens of epiphyseal coxa vara described in the literature. They range from cases with little displacement of the head, as in Case 1 of Frangenheim's second communication, to complete separation, as in Sprengel's Case 2. From descriptions of the above specimens and roentgenograms of our own cases it is possible to sum up our present knowledge of the pathology of epiphyseal coxa vara as follows: In an early case before any displacement has occurred we have a normal hip with a normal collo-diaphyseal angle of the femur. The head of the femur is in its normal position and is covered by normal articular cartilage. There is no bone atrophy or softening. The only abnormality thus far detected is a slight broadening of the cartilage of the epiphyseal line. At this period some change occurs in the region of the epiphyseal line which causes a weakening of the structures which bind the head to the neck of the femur. The nature of this change is unknown, as no such case has ever been studied pathologically.

The head of the femur being loosened in its attachment, begins to slip downward upon the neck. As the head moves downward the cartilage covering the upper part of the head and the adjacent periosteum is stretched and finally there is a tear, which usually occurs at about the border of the

cartilage. Before the tear occurs the cartilage of this region is thinned out slightly and assumes a bluish tint from the shining through of the underlying cancellous bone. The cartilage of the lower portion of the head is in the early stages normal. The periosteum of the lower portion of the neck may be torn across, but usually remains intact and is stripped up from the neck for a short distance.

As the head slips downward the leg tends to rotate outward, and the head, being fixed in the acetabulum, moves backward upon the neck. The displacement of the head is progressive over a period of from one to three years and naturally varies at different times in the same case as well as in different cases. In some cases there is a torsion of the head upon the neck, the head assuming a position of flexion while the femur moves in the direction of extension. In such cases the periosteum, which usually maintains its attachment to the head in much of its circumference, is slipped upon the mesial portion of the neck and its fibres assume a spiral direction, those upon the front of the neck coursing upward and backward to the epiphyseal line. On section of such a specimen it is found that the epiphyseal cartilage is moving with the head. The epiphyseal line is broad and irregular. Unless there has been considerable disuse there is no appreciable bone atrophy.

Microscopic examination in the early period of displacement reveals an epiphyseal line broadened and more vascular than normal. The cells have lost their orderly arrangement in columns and are scattered irregularly through the cartilage matrix. The bone and marrow of the head and neck are essentially normal. There may be an increase in the number of bone cells, and islets of cartilage may be scattered through the marrow in the vicinity of the epiphyseal line. There is no necrosis. The articular cartilage is normal in structure though thinned out on the upper part of the head.

As the head moves downward and backward it rotates upon the lower and posterior border of the end of the neck which sinks into the cancellous tissue of the head. The projecting lower and posterior borders of the head approach the corresponding surfaces of the neck. The result is an apparent shortening of these surfaces of the neck from the encroachment of the head. The upper and anterior portions of the mesial end of the neck, which are laid bare by the departing head, become covered with fibrous tissue and serve to extend the anterior and upper surfaces of the neck, causing the lengthening of these surfaces.

The head having assumed its final position on the neck, the processes of repair and readjustment set in and continue until adult life when the

bones assume their final form. It is to be remarked that the processes of repair and readjustment probably begin soon after the epiphysis begins to move, but are thwarted by the continued migration of the head. The repair consists in the binding of the head firmly to the neck. This is accomplished by the laying down of new bone in the region of the epiphyseal line and in the area between the lower and posterior surfaces of the neck and the overhanging head. There is a certain amount of atrophy of bone in the upper part of the neck and considerable atrophy of bone and articular cartilage in the lower and posterior parts of the head which are no longer in contact with the acetabulum.

In the process of readjustment there occurs a rounding off of the mesial ends of the upper and anterior surfaces of the neck, which are now in contact with the acetabulum, and a remodeling of this surface and of the upper and anterior portions of the head to form the new articular surface of the femur. There is also a remodeling of the acetabulum in an attempt to accommodate this new articular surface. The overhanging lower portion of the head may largely disappear. On section in late cases the head is sickle-shaped and there is considerable change in the internal architecture of the neck. The principal change is the thickening of the compact bone along the lower border of the neck to meet the increased strain due to the lessened mechanical efficiency of the neck of the femur. The pelvis becomes deformed on the affected side (ischium varum) as a result of the altered mechanics of the hip.

Microscopically, in the later stages there is the same disorganization of the epiphyseal cartilage as in the earlier stages. Enchondral ossifications are present and bony lamellae are invading the cartilage. There may be some fibrosis of the marrow with fibrillation of the cartilage matrix. In the lower part of the head there is marked atrophy of bone and there may be more or less necrosis of bone and cartilage cells. In cases in which the head has been suddenly moved a considerable distance by trauma there is the usual hemorrhage into the tissues and joint followed by the laying down of fibrous tissue and callus to unite the head to the neck in its new position. In such cases there seems to be a tendency to necrosis of the bone and marrow of the head, though the cartilage remains viable. Microscopically, in such cases extravasated blood and necrotic bone and cartilage are described. In the specimen described by Kappis the bone and marrow of the entire head were necrotic. This is unusual. As a rule the head remains viable.

The readjustment occurs in these traumatic cases just as it does in those that progress gradually. The final result is a thick neck with short sharply curved lower and posterior borders and long convex upper and anterior

borders, which is capped by a deformed head. The neck appears to be bent downward and backward and the collo-diaphyseal angle as measured from the center of the head through the base of the neck is usually about ninety degrees. The neck is bowed upward and anteriorly, and on its elongated upper and anterior borders at about the junction of the middle and inner thirds there is a bony prominence (the original points of attachments of the upper and anterior borders of the head). The deformed head is directed inward, downward, and backward. The acetabulum and pelvis are modified as noted above.

ETIOLOGY

Very soon after the condition of epiphyseal coxa vara was accepted as a definite clinical entity its etiology became a subject for controversy. The many theories as to the cause of the condition can be grouped roughly under the three main headings as follows:

(1) DISEASE, INCLUDING ENDOCRINE DISTURBANCES; (2) STATIC; AND (3) TRAUMATIC

1. *Theory That Epiphyseal Coxa Vara is Due to Some Abnormal Weakening of the Bone.* This is the first theory in point of time. Fiorani believed that his cases were due to rachitic softening of the neck of the femur. Kocher's[8] first case was resected in 1883 and at that time diagnosed adhesive arthritis. Monks[4] believed that he was dealing with an unusual case of arthritis deformans. Muller[6] thought that his bending of the neck of the femur was due to adolescent rickets, though no evidence of rickets was found in the excised specimen. Keetley[5] likewise diagnosed his case as adolescent rickets.

The first specimen showing pathology was one of Kocher,[8] reported in 1894. In this specimen areas in the neighborhood of the epiphyseal line were regarded as being typical of osteomalacia. Kocher first noted that the deformity occurs in the epiphyseal line, and while he supported the static theory he believed that in certain cases the femur was weakened by a juvenile osteomalacia localized in the femoral neck. As noted above, adolescent rickets played a prominent part in the theoretical origin of the earlier writers, then it apparently fell into disrepute for some years, though Hofmeister emphasized the adolescent type of Mikulicz[42] as being especially prone to develop coxa vara. In 1902 Haedke,[33] in his microscopic studies of a specimen from a typical epiphyseal coxa vara, noted changes in the region of the epiphyseal line which he regarded as being characteristic of

rickets. Peltesohn[43] regarded rickets as being the most important etiologic factor, though he admitted the influence of trauma in certain cases.

Later writers have revived the theory of late rickets. Bloch,[44] in a rather extensive study of fractures of the neck of the femur in young persons, is impressed with the fact that late rickets is a definite clinical entity and that the pathologic findings in the specimens of epiphyseal coxa vara of earlier writers can be interpreted as rickets. He considers the condition a deformity of adolescent rickets. Fromme,[45,46] in his extensive studies on late rickets (ninety-eight adolescent and five adult cases) as encountered in the population around Gottingen during the recent period of food privation due to the World War, does not hesitate to include epiphyseal coxa vara among the surgical conditions due to late rickets and war osteomalacia. He reports no case in detail but states that two cases of traumatic coxa vara were seen in the clinic and both showed roentgenographic evidence of late rickets. In seven cases of epiphyseal coxa vara treated at the Zurich clinic, Frösch[47] found evidence of rickets in six and the other patient was a woman twenty-eight years old who probably had had late rickets.

Arthritis deformans was suggested by Monks and Charpentier[48] (quoted from Lauper[49]), and Maydl regarded the juvenile type of arthritis deformans as being one of the causes of essential or non-traumatic coxa vara. Freiberg[50] in reporting two cases of epiphyseal coxa vara regarded them as a form of osteoarthritis deformans and did not operate to correct the deformity because he believed the bone to be the seat of trophic disturbances (his first case resembled an old Legg's disease).

Frangenheim,[38,39] on a basis of six resection preparations, definitely differentiated epiphyseal coxa vara from osteoarthritis deformans juvenilis and found no evidence of rickets in any of his specimens. In all of his specimens he noted some abnormality in the epiphyseal cartilage. He interpreted this abnormality as a growth disturbance and classed it as a localized form of chondrodystrophy. Frangenheim[38,39] considers the adolescent habitus of Mikulicz as being of great importance and states that by one familiar with the clinical picture of adolescent coxa vara the condition can be diagnosed at a glance. He regarded the epiphysis as slipping on a neck which was already diseased and considered true traumatic separation of the upper femoral epiphysis in a normal adolescent as being a very rare occurrence. A somewhat similar view was held by Schwartz,[51] who stated that traumatic separation of the upper epiphysis of a normal femur is not possible and that the condition is always the result of some as yet unknown disease of the cartilage.

The theory that in epiphyseal coxa vara the neck of the femur is the seat of a low grade osteitis due to infection was advanced by Froelich[52, 53] in 1904 after he had obtained cultures of staphylococci from material obtained by boring into the trochanter in two cases of coxa vara. Recently[54] he has recorded a case of Legg's disease which was observed from 1905 to 1917. In 1917 the picture resembled an epiphyseal coxa vara and Froelich concluded that the two conditions are stages in the evolution of a single malady which is an osteitis of the femoral head and is generally due to staphylococci. In his latest paper[55] he recognizes the effect of trauma in causing dislocations of the epiphysis but regards the trauma as being purely incidental in the evolution of the disease, the real cause of which is an epiphysitis. Platt[56] in a recent review of thirty-four cases of pseudocoxalgia does not mention epiphyseal coxa vara, but five of his cases (24–28 inclusive in Group III) classed by him as arthritis deformans juvenilis coxae, are typical examples of epiphyseal coxa vara. Platt's conception of the etiology is that the condition is due to an inflammatory lesion in the upper end of the femur, the changes being subchondral in location, the lesion being most probably due to an infection of low virulence carried to the femur by the blood stream. Poncet[57] naturally included epiphyseal coxa vara with genu valgum, flat foot, and scoliosis among the conditions due to his conception of inflammatory tuberculosis (toxic tuberculosis without tubercles and without bacilli in the locus of the lesion). Iselin[58] believes that the epiphyseal line is weakened by a nutritional disturbance similar to that which in his opinion causes Legg's disease.

Hofmeister[7] and others among the earlier authors emphasized the frequent occurrence of the adolescent type of Mikulicz[42] in patients with coxa vara. This is not the typical fat boy but is the overgrown boy or girl with large bones and large epiphyses, with rather flabby, weak skeletal musculature, and rather more subcutaneous fat tissue than is usual. These patients after prolonged standing with the hands at the sides tend to develop cyanosis of the extremities with mottling and coldness of the hands and feet. As was noted by Mikulicz, the type is frequently seen in cases of adolescent genu valgum and flat feet.

With the rise of endocrinology more attention is being paid to the habitus of the adolescents who develop epiphyseal coxa vara, and recent authors are emphasizing the frequency of its occurrence among fat boys and girls. To many, it is an endocrinopathy or constitutional disease. Stieda[59] noted increased knee jerks and ankle clonus in two cases. The adenoids and tonsils were enlarged and he considered the condition as the result of a lymphatic chlorotic constitution with softening of the bones, especially in

the region of the epiphysis, and possibly some disturbance in thyroid function.

Kirmisson,[60] formerly the champion of the traumatic theory in France, has recently been impressed with the frequent association of epiphyseal coxa vara with obesity[61, 62] and by the tendency of the condition to be familial. He reports several cases in obese children and he noted four cases in one family and two cases in another family. He states that obesity can cause various bone dystrophies and that this establishes a relation between it and coxa vara. In his cases the sellae were normal but development of the genitalia was retarded. He regards the condition as being due primarily to thyroid insufficiency. Vieullet's[30] five cases all occurred in obese girls. Pidlon[63] was impressed by the frequency with which coxa vara occurred in fat boys of feminine type.

Hass[64] found more or less outspoken constitutional abnormalities in all cases. They were the overgrown eunuchoid or fat types with genital hypoplasia and persistence of epiphyseal lines. To him the genital hypoplasia is the primary cause and trauma seems to be merely incidental. Riedel[65] believes epiphyseal coxa vara to be due to an irregularity of the growth of the bone and cartilage in the epiphyseal line, similar to the process in Legg's disease and possibly of an endocrine or infectious nature. Whitman[23] finds the fat boys especially susceptible to traumatic epiphyseal coxa vara. Four of the seven recent cases at the Massachusetts General Hospital reported by Wilson[32] occurred in excessively fat patients (three boys with feminine habitus and one girl with infantilism). In two cases the basal metabolism was normal and there was no evidence of rickets. Wilson believes that endocrine disturbance, probably of the pituitary, plays a part in the production of the condition.

2. *Static Theory.* The static theory in its original form explained epiphyseal coxa vara as being the result of a bending of the neck of the femur by superincumbent weight. It stressed the plasticity of growing bone and assumed that in epiphyseal coxa vara the weight borne was out of proportion to the strength of the bone. Muller,[6] perhaps, may be regarded as the founder of this theory, but he assumed that the bone was weakened by rickets. So it remained for Hofmeister[7] to first propose the static theory as outlined above and he was its foremost champion for many years, defending it on numerous occasions and never at any time admitting that the affected hip was the seat of any disease. In later years[13] he admitted traumatic separation of the epiphysis as the cause in a small percentage of the cases, but sharply differentiated these cases from his essential or static coxa vara of adolescence. He emphasized the adolescent

type of Mikulicz as occurring frequently among his cases. He also emphasized the effect of prolonged standing, especially with weight-bearing, as being a prominent causative agent. His long series of patients was largely from the laboring class. Manz[27] followed Hofmeister's views very closely. To him epiphyseal coxa vara was largely an occupational disease and might be called "Bauerbein" (farmer's bone), just as genu valgum was often called baker's bone. He explained at length the mechanics of the development of the deformity in field workers.

Hoffa[66] supported the static theory in the non-traumatic cases, and Helbing[19] in reporting the cases from his clinic considered epiphyseal coxa vara as a symptom which often followed excessive strain on growing bone.

Kocher[8] first noted that the deformity is localized in the epiphyseal region, and in one of his cases noted changes suggesting localized osteomalacia. For this reason he is generally credited as holding juvenile osteomalacia as a causative agent in all cases. This is unjust, as his work is really one of the foremost arguments in support of the static theory. Two of his cases occurred in cheese makers and he very carefully pointed out the unusual strain with the pelvis tilted backward, incident to this occupation, and its consequent effect upon the hip in adolescence. Lauper[49] reiterates Kocher's views, holding that the passive fixation of the pelvis offers the best explanation of the classical deformity.

Sudek[67] described a system of oblique bony lamellae in the femoral neck which passed upward and forward. The crest or ridge on the antero-superior surface of the neck near the epiphyseal line marked the termination of these lamellae. An hypothetical insufficiency of these oblique lamellae permitted the neck to bend down and back with weight-bearing, thus giving the typical deformity without assuming the presence of pathologic changes in the bone. Bahr[68] regarded Sudek's theory of primary insufficiency of the bony bow as untenable on mechanical grounds and stated that the roughness on the antero-superior surface of the neck had nothing to do with weight-bearing, but was the point of attachment of strong fibres in the capsule. He, nevertheless, considered excess weight-bearing as the causative agent.

Von Blum[69] in four patients who had lost the ability to bear full weight on one leg noted coxa vara in the sound hip. Two of his cases were of old tuberculous hips with coxa vara on the unaffected side. In several museum specimens with unilateral hip disease there was coxa vara on the unaffected side. In most cases there was no bone disease to explain the condition. He concluded that the weight of the pelvis was sufficient to explain all forms of coxa vara, and that pure congenital and pure traumatic cases

without static cause are very rare. A very unusual modification of the static theory is that of Jaboulay[70] and his pupil Picqué.[71] They considered epiphyseal coxa vara as the result of a process of compensation by nature in an effort to correct various asymmetries in the lower extremities, such as inequality in length, genu valgum, and flat feet. Another bizarre theory is that of Böhm[72] who cites the flattening of the neck of the femur in the anthropoid apes and so regards coxa vara as an ancestral rest. To him there are early and late congenital deformities. The late congenital deformities are due to primary morphological developments which under the influence of weight-bearing result in vicious development. Epiphyseal coxa vara is then a congenital deformity which develops during adolescence. Herz[73] takes issue with Böhm and points out that in the higher apes the neck of the femur is not in varus.

Two other modifications of the static theory deserve mention. Whitman[23] holds the static theory for his non-traumatic cases but believes that the coxa vara occurs in those adolescents in whom there is a mechanical predisposition to the deformity. This predisposition is a slight depression of the neck, usually due to early rickets, which subjects the part to increased strain and produces coxa vara in adolescence.

Drehmann[20] takes what he calls a middle ground, considering both statics and trauma as being of importance in producing the deformity. However, he also notes a mechanical predisposition to epiphyseal coxa vara. He studied the unaffected hips of his unilateral cases and found marked anterior torsion of the femoral neck on the sound side. The neck was usually longer and steeper than normal. An abnormal static or traumatic strain on a long, steep neck with anteversion caused an acute or chronic separation of epiphysis of the growing bone

3. *Traumatic Theory.* Sprengel[9] first showed that traumatic separation of the upper femoral epiphysis could result in a clinical picture identical with the coxa vara of Kocher and Hofmeister. In both of his cases there was a history of trauma followed by disability. At operation the epiphysis in each case was markedly displaced and reattached to the neck. Microscopic study of the specimens revealed no evidence of disease of bone or cartilage, but the picture of a healing epiphyseal separation. He introduced the term traumatic coxa vara and regarded the traumatic as being much more frequent than the static coxa vara.

Rammstedt[36] in his resection specimen found beginning bony union between the displaced head and the neck and a beginning disappearance of the epiphyseal cartilage line. In order to test the traumatic theory he performed ten experiments upon cadavers of individuals aged eight

to seventeen years. He was not able to produce typical epiphyseal separation, as usually a fragment of the neck was broken off with the head. He concluded that it was possible by trauma to loosen the head but not to displace it, because the strong periosteum bound it firmly to the neck. Epiphyseal coxa vara then was due to trauma, but in many cases the trauma served merely to loosen the head from its attachment to the neck and afterward the continuous strain gradually produced the deformity. In other cases there was a definite acute traumatic displacement.

Schlesinger[37] considered his case to be a purely traumatic separation in a normal femur. He considered the epiphyseal line as the locus minoris resistentiae in normal adolescents, and emphasized the fact that in every case reported the bend was in the epiphyseal line.

Kempf[74] in reporting sixteen cases from Sprengel's clinic found definite trauma in ten and was not able to exclude it in the other six. There was no difference between the two groups and no other pathology was present. To him every painful hip in adolescence was strongly suspicious of coxa vara, and there was no coxa vara except traumatic coxa vara.

In Abrahamsen's[75] series all were considered traumatic and compensated as such. In older cases the trauma was usually direct in character. In some instances the condition was thought to be a summation of the results of repeated slight traumata which develop a pathologic condition in the femoral neck, thus paving the way for the final trauma which results in the displacement.

Fittig,[76] on the basis of two cases in which the early radiograms showed a traumatic type of epiphyseal separation and which later exhibited the picture of the typical coxa vara statica of Hofmeister, concluded that the static theory was purely hypothetical but that the traumatic theory was clearly the solution in a great number of cases. Lorenz[77] regarded epiphyseal coxa vara as merely a special form of fracture of the neck of the femur. Grashey[41] considered his case traumatic and Seibs[78] noted trauma in his cases, but often the trauma was of minor character. Hoffa,[79] Whitman,[23] and Hofmeister[13] recognize trauma as the cause in certain cases. Elmslie[80] considered most cases to be purely traumatic in origin but in certain cases he recognizes a weakness or imperfect ossification similar to that found in the epiphysis in genu valgum. Steindler[22] states that in adolescents nine to sixteen years of age under certain traumata, epiphyseal separation is probable, and that epiphyseal coxa vara is a hazard of adolescent life just as fracture of a neck of the femur is a hazard of senility.

DISCUSSION OF THE ETIOLOGY

We have, then, three main theories to explain epiphyseal coxa vara. Beginning with the simplest, they will be considered in the order of their complexity, viz: traumatic, static, and disease of the bone.

The traumatic theory assumes that in the normal adolescent the capital epiphysis of the femur may be loosened or separated by trauma, which in many instances is very slight and may even pass without immediate symptoms and be forgotten by the patient. It is not to be denied that trauma often inaugurates the symptoms in epiphyseal coxa vara. The essential point is whether or not the upper end of the femur was normal when the trauma caused the epiphyseal separation. If the degree of trauma encountered in the average case of epiphyseal coxa vara were sufficient to cause epiphyseal separation in the normal adolescent, then epiphyseal coxa vara would be almost universal because the average adolescent suffers a number of such injuries yearly. Lorenz[77] regarded epiphyseal coxa vara as merely a specialized form of fracture of the neck of the femur and saw no reason to assume any predisposing bone pathology to explain the condition. By specialized, he meant that the fracture occurred in the epiphyseal line. There is a more important difference between epiphyseal coxa vara and the traumatic fracture of the neck of the femur. It is that epiphyseal coxa vara is frequently bilateral. In Hofmeister's experience, one-third of the cases were bilateral, and in the two hundred and fifty cases referred to above, many of which were traumatic, fifteen per cent. were bilateral. Fracture of the neck of the femur is relatively much more frequent than epiphyseal coxa vara, yet very few bilateral cases are recorded. There is then some predisposing factor which weakens the attachment of the epiphysis to the neck.

It is probably true that the epiphyseal line is the locus minoris resistentiae in the adolescent hip (Key[26]). This being true, cases of true traumatic separation of the upper epiphysis of a normal femur undoubtedly occur. In these cases the trauma is severe in character. Such cases are very unusual and it is not always possible to differentiate them from the usual cases with slight or no trauma. It is also probable that there are a great many adolescents who pass through a phase in which the epiphyseal line is weaker than normal but in whom epiphyseal coxa vara does not occur, because of lack of adequate trauma at the right time.

The static theory as advanced by most of its adherents infers that growing bone is less able to stand strain than is adult bone and that in many adolescents there is a disproportion between the superincumbent weight and the strength of the femoral neck. Such cases develop coxa

vara by gradual bending downward of the neck. In the description of the pathology as given in this paper it has been emphasized that the neck is not actually bent but the epiphysis is displaced and the neck remodeled by absorption and laying down of bone to meet the altered mechanics of the hip. If the static theory were true, practically all cases of epiphyseal coxa vara should be bilateral, just as cases of rachitic coxa vara are bilateral.

Advocates of the static theory should consider the normal factor of safety in the adolescent femur. I have not been able to find or furnish any data on this subject, but in adult femora the factor of safety in a man running at full speed is five and five-tenths, according to Koch.[81] Dixon[82] found that vertical pressures of eighteen hundred to twenty-five hundred pounds were necessary to cause fracture of the neck in a series of adult femora. As interruptions of continuity in the neck and epiphyseal line are rare in adolescents, and fractures of the neck are fairly common in adults, it is reasonable to assume that the factor of safety in adolescence is at least five or more. This being true, it is difficult to understand the giving way of a normal adolescent femur under the influence of obesity or hard labor. In other words, in epiphyseal coxa vara there is undoubtedly some weakening in the epiphyseal line which is the real primary cause of the condition.

The superincumbent weight is undoubtedly of importance in most cases and with muscle pull determines the direction in which the epiphysis moves, but it must act on a bone of less than normal resistance. Jaboulay's modification of the static theory is obviously speculative. Drehmann's finding of anteversion and an increased angle of the neck and Whitman's suggestion of a slight decrease in the collo-diaphyseal angle have not been present in the sound hips in our series. In our series the unaffected hips were normal except that in some instances there appeared to be a broadening of the epiphyseal line. Against the findings of von Blum we have the observations of Hoessly[83] who studied the sound hip in ten patients who were severely crippled on one side. In no instance was coxa vara present in the unaffected hip.

In the discussion thus far it has been emphasized that trauma and static influence are both important factors in the development of epiphyseal coxa vara but that they must act upon a femur in which the head is less firmly attached than normal. This fact has been recognized by numerous observers, and a number of them have tried to explain the weakening by disease. The condition most often incriminated is rickets or rather that vague, and in this country almost unknown clinical

picture, adolescent or late rickets. In our cases stigmata of rickets were noted in only one case. This, however, is of rather minor importance as an enthusiast could undoubtedly find some stigmata in almost every adolescent and particularly in those of the type prone to develop coxa vara. What is of much more importance is that in rickets the bones are softened and bend in the diaphysis, while in epiphyseal coxa vara the condition is a displacement, either gradual or sudden, of the epiphysis. This is emphasized below in the differential diagnosis between rachitic coxa vara of children and epiphyseal coxa vara of adolescence. It is further to be noted that in frankly rachitic children I have never seen a case of separation of any epiphysis, nor have I been able to find a single such case in the literature.

Fromme, dealing with adolescent rickets, states that separation of all growth zones is frequent. His evidence is meager, consisting of three cases of separation of the apophysis of the olecranon which he classed as adolescent rickets. If this is true, then adolescent rickets is a very different condition from the rickets of childhood and should be given another name. The only one of the excised specimens in which the diagnosis of rickets was made was that of Haedke[33] and this need not be taken seriously as all of his objective findings can be explained by purely traumatic separation. In two cases in which blood calcium and phosphorus determinations were done, they were found to be normal or high (Wilson[32]).

Kocher's theory of localized osteomalacia has never been taken seriously as applying to all cases, even by himself. His findings might easily result from traumatic separation with resultant necrosis and atrophy. Frangenheim frankly admits that he is unable to diagnose the condition but that there is something abnormal in the epiphyseal line in all of his cases. He attributes it to a disturbance of growth (chondrodystrophia of unknown nature).

The infectious theory rests solely on two positive cultures of staphylococci obtained at operation by boring into the trochanter (Froelich[52]). So slender is this evidence, that Froelich does not refer to it in his recent paper[55] in which he reports a case of Legg's disease as a precursor of coxa vara of adolescence, although he reiterates that both are due to staphylococci of low virulence. No case has ever suppurated except after operative interference, and in none of the specimens examined was there any suggestion of a reaction to an infection. The infectious theory may be discarded. It would be a very unusual organism which would invariably attack the upper femoral epiphyses.

In regard to the various endocrine theories very little can be said as very little is known. It is undoubtedly true that obese adolescents are more likely to develop epiphyseal coxa vara than are adolescents of the normal or slender type. In our series of twenty-four cases, five were obese and one was a boy of fifteen of the so-called feminine type. In none of them were there symptoms of myxoedema or pituitary disturbances other than the obesity, except in the case mentioned.

What then is the nature of this disturbance which causes a weakening of the epiphysis of one or both hips in certain apparently normal, healthy adolescents? Its pathology is unknown because no case has ever been studied early enough. In all of the specimens reported the original pathology has been obscured by trophic changes in the epiphysis incident to the disturbance in the blood supply and by nature's attempt to repair the lesion by reattaching the displaced epiphysis.

There are two factors which may have some bearing on the occurrence of the condition and which I have not seen mentioned in a rather extensive study of the literature involving a review of about three hundred papers. The first point is that the difficulty may not be in either the bone or in the epiphyseal cartilage. In childhood and early adolescence the periosteum of the femoral neck is very thick and strong and in places thrown into folds or ridges (the retinaculae of Weitbrecht). This strong periosteum spans the epiphyseal line and is the chief factor in holding the head in place. Harte[84] states that with the periosteum severed, only one-fifth of the force is necessary to cause epiphyseal separation as when it is intact. In adolescence this periosteum begins to atrophy and approach the adult type, thus tending to produce a point of weakness at the epiphyseal line (Key[26]).

The second point is that in every case that I have ever seen the parents have stated (only after direct questions in regard to the growth of the child, it is true) that during the period in which the lesion began the boy or girl grew very rapidly ("suddenly shot up like a weed" is a very usual answer). Unfortunately we have no measurements to substantiate these statements in regard to rapid growth. We have noted in our roentgenograms that in some instances the epiphyseal line of the opposite hip seemed to be unusually broad and well defined. It is not difficult to imagine that during this period of rapid growth the periosteum spanning the epiphyseal line is stretched, thinned, and consequently weakened, thus permittin the head to be easily loosened. Is this a disease or is it physiological? I do not know, yet it seems to be the most logical explanation of what occurs.

THE MECHANICS OF EPIPHYSEAL COXA VARA

The epiphysis being loosened, the head of the femur remains in the acetabulum with the ligamentum teres intact, while the diaphysis moves upward, rotates outward, and is usually twisted in the direction of hyperextension. The movement of the diaphysis upward on the head is obviously due to the effect of body weight in the upright position and also to the pull of powerful muscles spanning the joint. The external rotation of the leg is less easily explained. It is in part explained by the imbalance of the rotators of the hip, the external rotators being stronger than the internal rotators. This imbalance is increased by the change in the mechanics of the ilio-psoas. This muscle being attached posteriorly on the lesser trochanter acts as an external rotator of the distal fragment when there is an interruption of continuity between its insertion and the head of the bone. Its action becomes similar to that of the biceps on the forearm. The explanation of Kehl[85] that the ilio-femoral ligament is shortened and being attached posteriorly pulls the diaphysis into external rotation is not, I believe, to be accepted without reserve. It is true that this would be the action of postero-inferior fibres of the ligament if the displacement were marked. However, in most cases of epiphyseal coxa vara, the displacement is relatively slight. But even with marked displacement the upper band of the ilio-femoral ligament which runs from the anterior inferior spine across the upper and anterior part of the neck to the anterior border of the great trochanter would tend to act as a powerful internal rotator of the shaft and counterbalance the effect of the lower branch of the Y with its posterior insertion. Kocher's theory that in weight-bearing the hips are rotated outward to afford a broad base may perhaps have some foundation, but we feel that the hip is stronger and more stable when in the mid position or slightly internally rotated. His argument that in fatigue the hips are rotated outward, thus permitting the body weight to be borne by the ligaments, is perhaps of more weight but not sufficient to explain the moving forward of the neck on the head.

Harte's[84] theory that the head is pulled into the new position by the contracture of the intact periosteum below and behind the neck is inadequate, as it must be explained why this periosteum is not torn. It seems to me that the logical explanation lies in the normal anteversion of the femoral neck. In the normal femur with the leg in the neutral position the neck of the femur is inclined forward from twelve to fourteen degrees. This being true, with the body in the erect posture the thrust on the femoral

head is downward, backward, and outward. The tendency is for the head to slip out of the acetabulum at its upper and anterior portion, just where the two limbs of the Y-ligament unite. The head being firmly held in the acetabulum, the stress is transmitted through the epiphyseal line to the neck. In epiphyseal coxa vara the epiphyseal region is unable to support the strain and the head is moved obliquely downward and backward on the neck.

The torsion of the head on the neck as noted by Kocher is not a constant finding. I am inclined to believe that it occurs only after the head has been displaced downward and backward. Then the head rolls under and behind the neck and only its upper and anterior portions are in contact with the acetabulum. The upper portion of the neck is bare and enters into the formation of the hip joint. The result is that the new joint surface on the femur does not fit the acetabulum. In movement in extension the head is probably locked between the neck and the posterior inferior portion of the acetabulum and the tendency is for the neck to twist on the head, the torsion occurring at the epiphyseal line. In flexion the head is released and the stump of the neck tends to impinge on the postero-superior border of the acetabulum. This is relieved by external rotation, when more of the head which lies behind the neck glides into the acetabulum. Thus by externally rotating the hip the range of the flexion is increased.

So much for the mechanics of the production of the typical deformity. The deformity being present, does it explain the clinical picture characteristic of the position? Not entirely. As stated above, the clinical pictures range from that of an acute hip with practically no motion, to a painless hip with fairly free motion but always limited in abduction and internal rotation. In certain instances the hip becomes acutely painful and practically no motion is permitted in any direction. In these instances the limitation is obviously due to muscle spasm. In the average case, however, the hip is not acutely painful and motion is painless but restricted in abduction, internal rotation, flexion, and extension. In severe cases of long duration with marked deformity there is undoubtedly some contracture of the shortened muscles which would hinder normal range of motion in the joint, as is evident from the fact that in certain cases after an osteotomy has been done it has been found necessary to divide the adductors in order to secure abduction of the extremity (Keetley[5]). It has been shown by Albert,[86] however, that without fibrosis and structural shortening in the muscles their mechanical disposition offers no obstruction to motion in coxa vara. However, the essential factor in the limitation of motion is

the disorganization of the hip joint itself. Not only is the femur adducted and externally rotated and at times hyperextended upon the head, but the head is deformed and is rolled partially out of the acetabulum. The position of the head is sufficient to explain in part the limitation of abduction and internal rotation, and to slightly limit flexion; because with the head in the neutral position in the acetabulum the femur is adducted, externally rotated, and hyperextended. Theoretically, these movements should be markedly increased. Practically external rotation is usually slightly increased. Adduction is about normal and extension is limited. Excess adduction is prevented by the soft parts and by the impingement of the lesser trochanter on the pelvis. Abduction and internal rotation are limited on account of the position of the femur in adduction and external rotation and also by the impingement of the denuded end of the neck on the upper and anterior parts of the acetabulum respectively. I do not believe that the pubo-femoral ligament is the most important cause of limitation of abduction as was claimed by Manz.[27] The limitations of flexion and extension are due to the fact that the bearing surface of the femur is elongated in the vertical direction. The head having slipped down, the upper part of the end of the neck becomes smoothed off and enters into the formation of the joint. The acetabulum becomes modified to accommodate the new bearing surface of the femur but the bearing surface is now egg-shaped, and in flexion and extension of the hip is rotating round its short axis. Consequently these motions are limited, as in full range of motion it would be necessary for partial subluxation of the head to occur at the extremes of motion. The tendency of the hip to rotate outward when flexed is explained above.

In certain old cases there is very little motion in the hip in any direction. This is probably due to fibrosis of the capsule anp to arthritic changes which gradually develop after a period of years.

The shortening is due, not to bending of the neck, but to a slipping upward of the neck on the head. The prominence of the trochanter is due to its elevated position and also to the fact that the head in its new position causes a relative lengthening of the upper border of the neck of the femur. Its prominence is accentuated by the muscle atrophy which is constantly present. This atrophy is due to disuse and involves only the affected extremity.

DIFFERENTIAL DIAGNOSIS

At present when roentgenograms are the rule in the examination of a joint lesion or injury, the positive diagnosis of slipping of the epiphysis

at the hip in an adolescent should rarely be missed. Yet it is most unusual for a case to be correctly diagnosed in the early stages.

Sprengel[87] in 1912 stated that of twenty cases seen in his clinic not one entered with a correct diagnosis. Most of the cases that I have seen had been diagnosed as tuberculosis of the hip. The difficulty is that coxa vara is not even considered, rather than that the two conditions so closely resemble one another.

To one familiar with the condition the characteristic history, the age and habitus (not always present) of the patient, and the position of the thigh in adduction and external rotation immediately suggest the diagnosis of slipping of the capital epiphysis of the femur.

In tuberculosis of the hip, the hip is adducted and internally rotated. Almost never is the combination of adduction and external rotation seen. Hofmeister states that it never occurs. However, Levy[88] reports a case in a boy nineteen years of age in whom the hip was adducted and strongly externally rotated. The roentgenogram showed what appeared to be a slipping of the epiphysis. The diagnosis of adolescent coxa vara was made and the hip manipulated. The boy developed general tuberculosis and died. Autopsy disclosed an old tuberculous hip with erosion of the upper part of the head and of the lower part of the neck near the epiphyseal line, giving a beak-like appearance to the lower border of the head as is seen when it slips down and projects below the line of the neck. This is a unique case in that it is the only one I have seen in the literature in which a tuberculous hip was diagnosed as adolescent coxa vara.

In tuberculosis the atrophy is greater and the hip usually more sensitive and painful even while at rest. Epiphyseal coxa vara may be acute but quiets down very quickly after fixation and freedom from weight-bearing. In an active tuberculous hip there is generally some fever in the evening. In coxa vara the temperature is normal. In case of doubt the radiogram ought to settle the difficulty except in a very unusual case such as that of Levy cited above. It is to be emphasized that in adolescence and especially in boys, slipping of the epiphysis is about as frequently encountered as is tuberculous coxitis.

In very rare juvenile arthritis deformans as described by Brunn,[89] Maydl, and others the difficulty of diagnosis may be much more pronounced. The physical findings are those of a mild coxa vara but the roentgenogram shows the arthritic changes in the joint with no displacement of the head.

In Legg-Calvé-Perthes' disease the history, limitations of motion, slight atrophy, and shortening are identical with those of a mild coxa vara. The chief differential points are the age of the patient and the X-ray appearance.

Legg's disease is a disease of childhood and rarely begins after the tenth year, while epiphyseal coxa vara rarely begins before the tenth year. In Legg's disease the lesion is in the epiphysis itself. The head is not misplaced but is deformed and may, in the mushroom type, overflow the borders of the neck. The evolution of the condition is well described in two recent articles (Waldenström,[90] and Perthes and Walsh[91]). In Legg's disease the direction of the epiphyseal line is changed to approach more nearly the horizontal; thus the flattened and broadened head approaches the great trochanter, and the upper border of the neck is shortened. In coxa vara the head slips down and away from the great trochanter, thus causing lengthening of the upper border of the neck, while the epiphyseal line approaches the vertical plane. In adult cases due to loss of the epiphyseal line and progressive changes in the head and neck it may be absolutely impossible from the roentgenogram to determine whether the original condition was a Legg's disease or an epiphyseal coxa vara.

Types of cervical coxa vara which may be confused with the epiphyseal type are the congenital, the rachitic, and those due to fracture of the neck of the femur in early life. There are a great many such cases in the literature. In the congenital type there may be other congenital deformities and there is usually a history of a peculiarity in gait since the child began to walk. The chief limitation is in abduction. The roentgenogram shows a very high trochanter with the neck arising from the shaft and pointing directly inward or even slanting inward and downward to a variable degree, the epiphyseal line being at a right angle to the neck. The deformity may be unilateral or bilateral. Rachitic coxa vara is always bilateral. It begins in early life and is accompanied by other stigmata of rickets. It is usually painless and the chief limitation of movement is in abduction. In the roentgenogram the neck is bowed upward and it is unusual for it to be at an angle of less than ninety degrees with the shaft. The epiphyseal line is not at a right angle with the neck but slants downward and inward while the head is directed upward and inward, encroaching upon the upper border of the neck. If there is such a thing as coxa vara due to late rickets arising in adolescence it must be of this type. I have never seen such a case nor have I been able to identify one in the literature, though there are a number of cases of epiphyseal coxa vara attributed to rickets.

Fractures of the neck of the femur in adolescence are most unusual (Hoffa[66]). In such a case a roentgenogram would be necessary to determine whether the lesion was in the neck or in the epiphyseal line. Fractures incurred in children and not adequately treated result in a coxa vara resembling the congenital or rachitic types mentioned above.

In closing the question of differential diagnosis, the most important point is that a traumatic or chronic hip beginning in adolescent life has about a fifty per cent. chance of being a slipped epiphysis. The reason that so many of these cases are falsely diagnosed is that the question of epiphyseal coxa vara is never considered. Once this is considered, the picture is as a rule quite characteristic.

PROGNOSIS

Epiphyseal coxa vara is nearly always due to a weakening of the attachment of the head of the femur to the neck. The cause of this weakening is unknown. I believe that the condition affects only the upper epiphysis of the femur. I have seen no case in which there were symptoms in any other epiphysis, nor are any such cases to be found in the literature. This limitation of the condition to the hip is usually explained on mechanical grounds, the statement being made repeatedly that no other epiphysis is subjected to such cross strain. The facts are that the epiphyses of the tarsal bones and the various apophyses are constantly subjected to cross strain, and yet there are no cases of coxa vara recorded in which these have been affected.

The condition apparently affects only the hips. There is no evidence that it is an infection or a general condition of any kind, hence the general health and life of the patient are not endangered, nor are any other joints likely to be involved.

The prognosis is then a question of what is going to happen to the involved hip and whether or not the condition will become bilateral. As regards the latter consideration, in fifteen per cent. of the cases from the literature the condition was bilateral. In Hofmeister's series one-third of the cases were bilateral. This discrepancy is partly due to the fact that Hofmeister was looking for bilateral cases and consequently examined the apparently uninvolved hip more carefully than did those who regarded the condition as being purely traumatic. It is also partly due to the fact that most of Hofmeister's cases were of the so-called static type. I have observed that cases of gradual onset with histories of slight or no trauma are very likely to become bilateral unless carefully handled.

The end-result in the hip affected depends to a certain extent upon the degree of displacement of the head, and may be modified by treatment. Hofmeister[25] noted that without treatment there was a tendency for the pain and muscle spasm to diminish and gradually disappear, and for some motion to be restored to the hip. In 1905[13] he stated that

twenty-three of twenty-nine of his patients had been able to return to their original occupations and were for the most part free from pain. In his cases flexion was restored to the greatest extent, then internal rotation, and lastly abduction. The possibility of spontaneous improvement in a severe case is so well shown in one of his figures that it is reproduced here (Fig. 8).

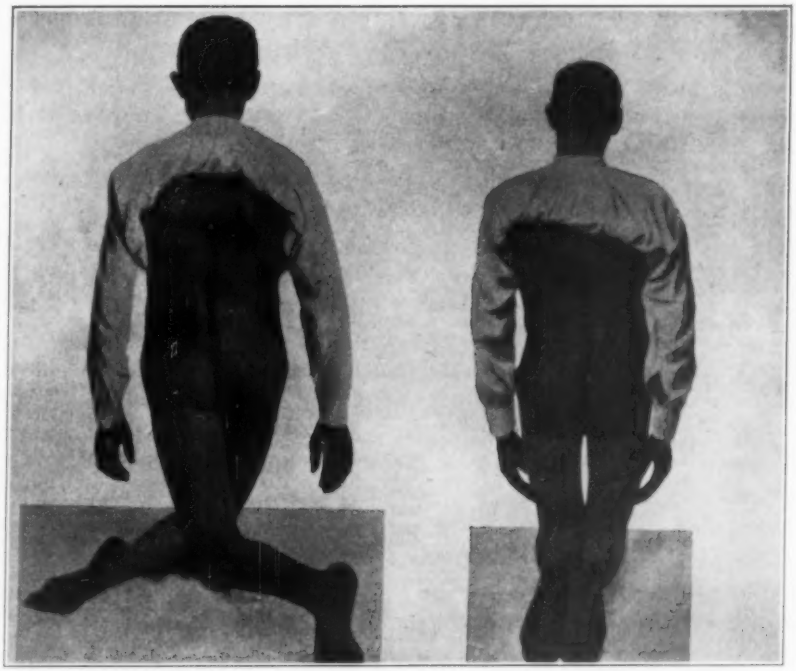

FIG. 8

Hofmeister's case showing spontaneous improvement after four years.

Brande,[92] in a very interesting report of seven cases which had no treatment or only a high shoe or rest in bed, found that abduction was restored on an average to about twenty-five per cent. and internal rotation to about twenty per cent. In eight cases treated by manipulation (refracture of Lorenz[77]) followed by fixation in plaster the results were not so good. In treated cases the average abduction was about twenty-five per cent. in six cases. In two cases there was ankylosis in flexion, and in no case was there restoration of internal rotation.

Abrahamsen,[75] in a series of old cases attributed to trauma, found disability of twenty-five to thirty per cent. as awarded by the council of assurance for laborers. In his series the displacement of the epiphysis was not completely reduced in any instance and he states that it is impossible for him to give a prognosis for such cases, but that in cases not reduced, an invalidity immediate and sometimes very marked will follow and will not diminish with the years. (Just the opposite of Hofmeister's opinion.)

The end-results of twenty-two cases treated at the Keil clinic in the period from 1899 to 1922 were recently investigated by Kappis.[40] He was able to get ten of these cases to report back for examination. Two cases treated by immobilization without reposition had severe deformity with pain and limitation of motion in the hip. One case treated by nail extension for two months showed a broadened head one and one-half years later, but the function was good. There were five cases of acute epiphyseal separation which were apparently reduced by manipulation and then immobilized in plaster. These cases as a rule result in a short neck surmounted by a deformed head. Kappis considered four of them as functionally perfect and the other as a fair result, though no data regarding the mobility of the hips are given in his report.

Of more than usual interest are two old cases reported by Schmidt[93] and one by Zehnder.[94] Schmidt regarded his cases as old contusions of the head of the femur, but they are typical cases of epiphyseal coxa vara. At the time of examination the patients were men of thirty-four and forty-five years of age respectively, who had entered the hospital complaining of pain and disability in the hip. Both had had trouble with the hip off and on since reaching adult life and entered the hospital with moderately acute coxitis deformans. In one case a subtrochanteric osteotomy was done and in the other the symptoms were quieted down by rest and physiotherapy. Zehnder's case was in a man of forty-two years of age. The condition was bilateral. It began spontaneously at sixteen years. At twenty years of age he had considerable pain. The hips then quieted down and gave him little trouble until he was thirty-five years old. At that time they became painful again and this condition persisted, the pain being severe in Winter until the time of examination by Zehnder seven years later. All of Platt's[56] five cases showed marked limitation of motion at the final examination and one of them was ankylosed.

Of our series of twenty-four cases at the Massachusetts General Hospital it has been possible to re-examine fourteen cases. These cases

TABLE II

Case	Hip	Length in Inches	° Thigh	° Calf	Flexion	Extension	Abduction	Adduction	Ext. Rotation	Int. Rotation	Perm. Flexion	Shortening in Inches	Atrophy Thigh in Inches
11.	Rt.	33	18½	13½	90	40	40	35	40	45			
M. C.	L.	32	16½	13	65	15	15	30	30	20		1	2
12.	Rt.	32	18¾	13	120	25	45	30	35	45			
S. L.	L.	30½	17¾	12½	75	0	35	5	15	0	25	1½	1
13.	Rt.	39½	20½	13½	135	25	45	35	45	35			
E. B. C.	L.	38¾	18¼	13¼	85	0	20	5	30	0	20	¾	2
14.	Rt.	33	18	12¾	110	45	35	30	40	35			
G. B.	L.	32½	15	12½	30	20	5	25	15	0		½	3
15.	Rt.	32¼	19½	12½	100	20	50	45	40	25			
T. J. D.	L.	31½	18½	12½	130	0	0	40	40	0	15	¾	1
16.	Rt.	29	21	15	80	10	25	25	35	0		¾	
S. R.	L.	29¾	21	15	115	25	40	25	45	35			

II. End results in cases which were not manipulated.

TABLE III

Case	Hip	Length in Inches	° Thigh	° Calf	Flexion	Extension	Abduction	Adduction	Ext. Rotation	Int. Rotation	Perm. Flexion	Shortening in Inches	Atrophy Thigh in Inches	
17.	Rt.	33½	18½	13½	45	0	0	10	5	15	30	1	2	
F. K.	L.	34½	10½	12¾	135	20	20	20	25	25				
18.	Rt.	30½	20½	14¼	20	0	0	0	0	0		1	1	
K. W.	L.	31½	21½	14¾	115	20	25	25	30	35				
19.	Rt.	31¾	19½	14¼	30	0	10	10	55	—10	10	¾	2	50° Ext. Rot. c Flex.
A. F.	L.	32½	21½	14	120	25	25	25	50	0				45° Ext. Rot. c Flex.
20.	Rt.	36½	19	12¼	115	25	25	25	45	45				
J. B.	L.	36	17	12	90	10	5	25	60	0		½	2	45° Ext. Rot. c Flex.
21.	Rt.	39	21	14½	60	15	5	25	40	10				30° Ext. Rot. c Flex
H. C.	L.	38½	21	15	15	0	15	20	35	—20	10	½		15° Ext. Rot. c Flex.
22.	Rt.	39½	20	13¼	115	25	45	25	40	35				
J. E. C.	L.	39	17	13½	20	0	10	15	30	0	15	½	3	50° Ext. Rot. c Flex.
23.	Rt.	38	19½	13¼	115	25	45	45	50	45				
M. K.	L.	36½	17½	13	50	10	10	25	20	0		1½	2	
24.	Rt.	37½	20½	14	130	35	45	25	40	45				
F. A. D.	L.	36¼	18¼	13	120	40	10	30	50	5		1	2¼	45° Ext. Rot. c Flex.

III. End results in cases treated by manipulation or operation.

were all examined according to a definite outline and the range of movement of the hips measured with a goniometer. The details of the hip examinations of these cases are given in Tables II and III. The five cases in Table II were not operated upon or manipulated. Eight of the cases in Table III were manipulated according to Whitman's method and one was operated upon. The case numbers correspond to those in Table I.

Abstracts of the histories of these cases are given below.

Case 11. M. C. October 23, 1918. About three years ago the patient began to have dull pain in the left hip and thigh during and after walking. Onset gradual without definite trauma. The pain was relieved by rest and did not trouble her at night. A limp developed and has persisted. The pain has been present off and on, and at times has been severe, especially after excessive exercise. At times the pain has disappeared entirely. The pain and stiffness seem to be getting worse.

P. E.: Slightly obese girl of thirteen years of age. Tonsils enlarged, otherwise normal except hip. The left hip is held in twenty-five degrees flexion and twenty degrees adduction and is externally rotated. Roentgenogram showed an abnormal relation of the epiphysis to the neck of the femur.

Treatment: Rest in bed, obesity diet, and pituitary extract.

December 1, 1918. Plaster spica and continued in either long or short spica with crutches until August 6, 1919 (eight months).

April 11, 1921. Re-examined She had a severe attack of influenza last year and has not been strong since. The hip troubles her very little unless she walks more than usual. Then she has a dull pain in the left hip and down the outer side of the left thigh to the knee. There is also a tired feeling in the back after exercising. She has difficulty in bending forward and in putting on the left shoe.

P. E.: Well developed and normal young girl. Weight, 114 pounds; height, 63 inches. No evidence of any endocrine disturbance. She stands with rather marked lumbar lordosis and there is a moderate scoliosis with some rotation on bending forward. She walks with a slight limp. She puts on the left shoe by flexing the knee fully and reaching down lateral and posterior to the left thigh. The roentgenogram resembles an old Legg's disease.

Case 12. S. L. March 13, 1920. About a year ago while running a pain developed in the left hip. This has persisted. The pain has never been very severe and at times almost entirely disappears. Limp and shortening developed.

P. E.: Well developed and normal boy of fifteen years of age. Walks with a moderate limp. Left leg one and one-half inches shorter and limited in flexion, internal rotation, and abduction to sixty-five degrees, minus fifteen degrees, and minus ten degrees respectively. There is thirty degrees of permanent flexion. The hip is not painful.

Treatment: Thomas walking splint worn for one year.

January 28, 1921. Re-examined. No pain in the hip. Is taking exercises in an effort to increase the motion in the hip. Attends school.

P. E.: Well developed, normal, and rather muscular boy. No evidence of any endocrine disturbances. Stands with marked lordosis and moderate scoliosis. Walks with a rather marked limp. The left trochanter is prominent and above Nélaton's line.

There is twenty-five degrees of permanent flexion in the left hip. Roentgenogram shows epiphyseal separation left (Figs. 9 and 21). Examination of the hip in Table II.

CASE 13. E. B. C. March 28, 1921. For at least three years the patient has had pain in the left hip off and on, especially after long walks. The onset was gradual and there was no definite injury to the hip. During the first year the hip was sore and painful. Recently he has been doing heavy work as a truck driver and the hip has been more painful.

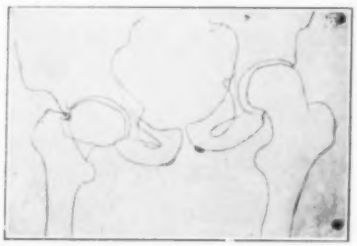

FIG. 9. CASE 12

FIG. 10. CASE 13

FIG. 11. CASE 14

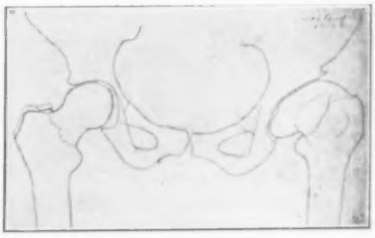

FIG. 12. CASE 16

P. E.: Well developed young man of nineteen years of age. Left leg short one inch with one and one-half inches of atrophy of the left thigh. The trochanter is prominent and above Nélaton's line. There is fifteen degrees permanent flexion of the hip. Flexion, internal rotation, and abduction are limited to fifty-five, twenty, and zero degrees respectively. The hip is not painful. Roentgenogram shows old slipped epiphysis.

Treatment: One-half inch lift on the left heel and exercises.

April 4, 1922. Re-examined. Well developed, normal, tall, rather slender young man; weight, 165; height, 73 inches. Now working as a tire finisher. Getting along very well, but has considerable pain in the hip after a hard day's work or a long walk.

P. E.: Stands with marked lordosis and moderate scoliosis. There is twenty degrees permanent flexion in the left hip. Roentgenogram Fig. 10. Hip examination in Table II.

CASE 14. G. B. January 24, 1921. Two months ago the patient was kicking a football and his foot struck a small rock. There was an immediate sharp pain in the outer side of the knee. The pain has persisted and is worse after exercise and relieved by rest. The pain has been felt only in the knee.

P. E.: Well developed, normal young boy of fourteen years of age. There is slight tenderness over external lateral ligament of the knee. The left trochanter is prominent and above Nélaton's line and there is one-half inch shortening in the left leg. Flexion, internal rotation, and abduction of the left hip are limited to sixty, zero, and minus five degrees respectively. The hip is not painful.

Treatment: Short plaster spica two months, then exercises one year.

April 11, 1922. Re-examined. Patient has had no pain since the removal of the spica, but the hip has remained stiff. He is unable to lace the left shoe. Exercises have not helped.

P. E.: Well developed, normal, rather muscular boy. Stands with moderate lordosis and slight scoliosis. The left trochanter is prominent and above Nélaton's line. No pain or tenderness. Roentgenogram shows old epiphyseal coxa vara (Figs. 11 and 15). Hip examination in Table II.

CASE 15. T. J. D. April 4, 1911. At twelve or fourteen years of age patient fell and injured the left hip. He walked lame for over a year and then gradually recovered. During the past two years he has been troubled by periods of severe pain and lameness in the left hip.

P. E.: Well developed, normal man of 45 years of age. Right leg 2 cm. short. Motion free. Roentgen-ray diagnosis: Question of shortening of neck, flattening of head, and exostosis of the great trochanter.

April 11, 1911. Operation. Exostosis of trochanter impinging upon the ilium and a small piece of the head removed. Uneventful recovery. No further treatment.

August 9, 1921. Re-examined. The patient is working as a janitor. Gets along very well but has some pain in the hip and knee after walking more than usual. He feels that he was markedly improved by the operation.

P. E.: Well developed, normal man of 55 years. Stands with slight scoliosis and the head of the femur mushroomed. The acetabulum is somewhat irregular (Fig. 25). Examination of the hip in Table II.

CASE 16. S. R. January 28, 1922. Patient complains of pain in the right hip and knee. The onset was gradual about two years ago. There was no injury or known cause. The pain is increased by activity and is getting worse. Lately she has had difficulty in stooping and in putting on the right shoe. She has gained thirty-two pounds in weight in the last three years. She states that she was quite active as a young girl and can recall no period of pain or disability in the hip.

P. E.: Rather obese young woman of thirty-two years. Roentgenogram shows short broad neck and mushroomed head with shallow acetabulum (Figs. 12 and 24). Hip examined in Table II.

CASE 17. F. K. Nov. 17, 1906. Two years ago patient injured right hip playing football. The condition was diagnosed as a dislocation of the hip. He was anaesthetized and the dislocation (?) reduced. He remained in bed two weeks, then gradually resumed normal activity. A limp persisted for some time but gradually disappeared. Four months ago, without any known cause, the hip became stiff. There has been no pain, but the stiffness is increasing.

P. E.: Well developed and normal boy of fifteen years of age. Walks with a marked limp. The right trochanter is prominent and there is bony thickening around the head and neck. There are two inches of atrophy of the right thigh. The right hip is held in extension, adduction, and external rotation. All movements of the hip are limited and painful. Roentgenogram shows the inner half of the neck of the femur to be thickened. The head is displaced and obscured by the neck.

November 19, 1906. Operation. Anterior incision. A bony surface covered with cartilage and facing forward was exposed. The anterior bony prominence was chiseled off, permitting increased flexion, and the wound closed. Plaster spica three weeks; then crutches.

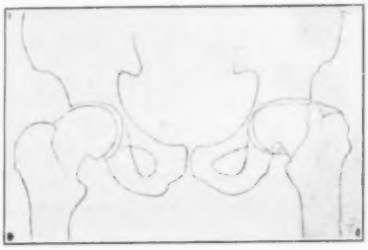

FIG. 13. CASE 19

FIG. 14. CASE 20

FIG. 15. CASE 21

FIG. 16. CASE 22

April 26, 1922. Re-examined. The hip is stiff but gives him little pain. Occasional attacks of pain in cold weather. Now working as a wool sorter. In 1918 he was discharged from the army on account of the stiffness of the right hip.

P. E.: Well developed and normal young man. Walks with a moderate limp. There is a moderate lordosis and scoliosis with slight rotation. The right trochanter is prominent. There are almost complete ankylosis of the hip, with twenty-five degrees permanent flexion on the right. There is some limitation of motion in the left hip. Roentgenogram not obtained. Hip examination in Table III.

CASE 18. K. F. M. May 13, 1912. Two years ago she fell and injured the right knee and hip. Lameness and pain in the hip developed and have persisted. The leg has shortened and turned out. Six weeks ago the hip became acute and the pain radiated to the lateral and posterior surfaces of the thigh and knee.

P. E.: Obese girl of twelve years, weighing about one hundred and thirty pounds. Tonsils large. Stands with the right leg everted almost ninety degrees. Abduction and internal rotation markedly limited.

May 16, 1912. Anaesthetized and the hip manipulated. A plaster spica was applied with the hip in full abduction. She wore a plaster spica for eighteen months and was then given a brace. Shortly after the operation she developed a facial tic.

April 12, 1921. Re-examined. The patient is still wearing a Thomas walking splint. The foot is in marked varus. The varus deformity developed six years ago and was thought to be a functional contracture. She has not borne weight on the foot for seven years, and refuses treatment other than the fitting of the brace.

P. E.: Well developed young woman. No evidence of any endocrine disturbance. Old facial tic is not present. There is a marked varus deformity of the right foot, with skeletal changes. Very little motion is permitted in the hip. Radiogram shows moderate epiphyseal coxa vara (old). Hip examination in Table III.

Case 19. A. F. July 24, 1916. In October, 1915, stiffness and dull pain developed in both hips. The symptoms appeared in the right hip first and soon afterwards in the left hip. In March, 1916, he was treated in the Salem Hospital. Traction was maintained on both legs. Since that time he has had no pain but the stiffness has persisted.

P. E.: Fat, flabby-looking boy of fourteen. Very slight hare lip. Pubic hair normal. Legs everted; positive Trendelenberg, bilateral. Hips limited in flexion, abduction, and internal rotation. No pain. Deformity more marked on the right.

August 1, 1916. Anaesthetized and hips manipulated. Double plaster spica applied with both hips in a thirty-five degrees abduction. Given obesity diet and pituitary extract until April 17, 1917. Wore plaster spicas six months.

March 21, 1922. Re-examined. Patient is now working as a clerk and has very little pain in the hips. If he walks more than usual a dull pain develops in the right hip. The stiffness of the hips causes him a good deal of trouble in sitting and in dressing himself. He regards himself as a cripple.

P. E.: Robust, muscular young man; medium height and weight. Walks with a moderate limp. There is slight scoliosis with structural change. Hips not painful but markedly limited in motion. Roentgenogram Figs. 13 and 23. Hip examination in Table III.

Case 20. J. B. October 18, 1918. About one year ago the patient had some slight pain in the left hip which caused him to limp. After a few weeks the pain and limp disappeared and there was no further trouble until six months ago, when he fell on the ice. There were no immediate symptoms but about two weeks later the pain and limp reappeared. During the summer months the symptoms disappeared but recently without known cause they have returned with increased severity. Relieved by rest. Sleeps well.

P. E.: Well developed boy of sixteen years of age. Normal except the left hip. Walks with a decided limp. Left hip held in full external rotation. There is one-half inch shortening. Flexion, internal rotation, and abduction are limited to sixty degrees, zero, and twenty degrees respectively, and there is pain in the hip at the limits of motion. Radiogram shows slight displacement of the epiphysis.

Treatment: Plaster spica. Spica continued five months.

March 24, 1919. Manipulated under ether, and spica reapplied. Spica and crutches four months.

February 8, 1921. Re-examined. General health good. He is now doing light work in a store. The hip troubles him occasionally, especially if he is on his feet more than usual, when he has a moderate pain in the left hip, front of the thigh, and inner side of the knee. At times he has a dull backache. There is difficulty in bending and lacing his shoe. He is wearing a one-half inch raise on the left heel.

P. E.: Well developed and normal young man. Weight, 127 pounds; height, 67 inches. No evidence of any endocrine disturbance. Walks with a moderate limp. Normal except hips. There is a moderate scoliosis with slight rotation on bending forward. The left trochanter is prominent and above Nélaton's line. There is rather marked atrophy of the left buttock. Radiogram of both hips. Slight deformity in right and typical in the left (Figs. 14 and 22).

CASE 21. H. C. Feb. 5, 1921. Four years ago the left hip was injured in an automobile accident. He was in bed one month but apparently recovered completely. About a year and a half ago pain developed in the left hip. This pain has become worse until now he is unable to put his weight on the hip without pain.

FIG. 17. CASE 23

FIG. 18. CASE 24

P. E.: Heavy, flabby boy of sixteen (adolescent type). The left leg is fixed by muscle spasm in fifteen degrees permanent flexion, ten degrees adduction, and forty-five degrees external rotation, and no motion is permitted. The tissues over the anterior surface of the hip are thickened and tender on pressure. In the right hip flexion, internal rotation, and abduction are limited to ninety degrees, zero degrees, and twenty degrees respectively. The right hip is not painful. Roentgenogram shows epiphyseal coxa vara on the left and a slight displacement of the right.

March 10, 1921. Anaesthetized and manipulated. Double spica applied with hips abducted to forty-five degrees. Post-operative roentgenogram showed epiphysis on the right slipped up into valgus position (Fig. 20). Spica worn three months, then abduction splint six months.

March 30, 1922. Re-examined. Patient is very large boy and has grown very rapidly, gaining four and one-half inches in height in the past year and a half. Weight now 185 pounds. Has had baking and massage to increase the motion of the hips. There is no pain but the hips are stiff. Hip examination in Table III (Figs. 15 and 20).

CASE 22. J. E. C. August 5, 1918. While in the navy eight months ago his foot slipped and he fell to the floor, striking on the left hip. About two weeks later pain and stiffness gradually developed in the left hip and thigh. The condition has gradually become worse and now the pain is constant and he has been unable to walk at all during the past two days.

P. E.: Well developed, normal boy of seventeen. He lies with the left leg flexed to forty-five degrees and adducted. The hip is fixed in this position and any attempt at motion is painful. Muscle spasm is marked. Plaster spica applied and two months later hip was put in traction two weeks. Then he was anaesthetized, the hip manipulated, and a double spica applied. Plaster spica worn six months.

March 27, 1922. Re-examined. Patient is now attending school. Recently he was rated as having fifty per cent. disability by the Veterans' Bureau on account of the hip. He is getting along fairly well but has some pain in the hip and thigh after walking more than usual. The stiffness in the hip troubles him a good deal and he desires an operation to obtain motion.

P. E.: Well developed and normal young man. Height, 70 inches; weight, 125 pounds. Normal type. Stands with moderate lordosis. There is slight scoliosis with some rotation. The left trochanter is prominent and above Nélaton's line. Roentgenogram Fig. 16. Hip examination in Table III.

CASE 23. M. K. October 4, 1919. About a year ago pain and weakness gradually developed in the left hip. Three months previous to the development of the pain he had a slight injury to the hip when he was thrown while playing football. The hip remained sore about a week then cleared up. The condition is getting worse.

P. E.: Well developed and normal boy of fourteen. Left trochanter prominent and above Nélaton's line. Left leg three-fourths of an inch short. Flexion limited to fifty degrees and abduction limited to twenty degrees. Attempt to force hip causes spasm and pain. Walks with marked limp.

October 7, 1919. Twenty-five pounds traction to left leg two weeks.

October 23, 1919. Anaesthetized, manipulated, and double plaster spica applied. Spica worn one month and abduction splint three months.

September 12, 1921. Re-examined. He is having no pain in the hip but the left leg is weak and stiffens after walking. Walks with a moderate limp. Roentgenogram Fig. 17. Hip examination in Table III.

CASE 24. F. D. May 6, 1921. Ten months ago pain developed in the left hip. It has gradually grown worse and the hip became stiff.

P. E.: Rather tall, slender boy of fourteen. Left leg everted, and motion in hip limited to forty-five degrees in flexion, five degrees in abduction, and minus five in internal rotation. The Trendelenberg is positive. Walks with a moderate limp. Roentgenogram shows epiphyseal coxa vara.

May 23, 1921. Anaesthetized, manipulated, and plaster spica applied. Spica worn three months, then abduction splint six months.

March 6, 1922. Re-examined. Patient is a normal, healthy-looking boy, rather tall and slender. He walks with a slight limp but has no pain. Roentgenogram Fig. 18. Hip examination in Table III.

In studying these fourteen cases we have divided them into two groups. Cases 11 to 14 inclusive were treated only by fixation and freedom from weight-bearing or corrective exercises. Cases 15 and 16 had no treatment until adult life when they entered the clinic for pain in the hip. These cases have, on the whole, fairly serviceable hips (Table II). They are all limited in abduction and internal rotation and all but one are limited in

flexion. In all these hips there is moderate range of painless motion. Shortening varies from one-half to one and one-half inches. Two of these patients have no pain. The other four have moderate pain after an unusual amount of exercise.

The second group (Table III) includes one operated case and seven cases in which the hips were manipulated under general anaesthesia. In Case 17 the operation was undertaken in an effort to remove a bony block in the hip joint. The end-result is a practically ankylosed hip. The other

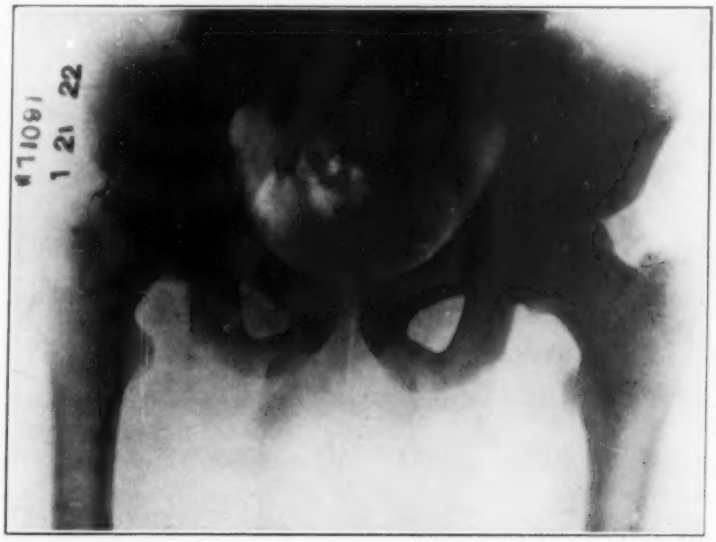

FIG. 19. CASE 14
Duration one year and two months.

seven cases were manipulated under ether anaesthesia according to the method advised by Whitman.[28] At the time of manipulation the full range of normal motion was obtained and the hips were fixed in the corrected position in plaster spicas. The results in these cases are definitely poorer than are those in the cases which were not manipulated. The average range of motion is less in the manipulated hips, and a larger percentage of them are painful after exercise. It is to be noted that in our series of twenty-four cases, thirteen were manipulated one or more times. In not a single instance was the epiphysis replaced in its normal position. Our series then gives us the prognosis only for cases in which the displace-

ment of the epiphysis is not reduced. In such a case the epiphysis, when it finally comes to rest, is united firmly to the neck in its new position with or without treatment. Non-union in these cases is practically unknown. The only recorded instances of non-union from epiphyseal separation at the hip are two cases mentioned by Campbell.[95] They are unique in the literature and should be reported in detail. Likewise the question of necrosis of the epiphysis need cause little concern. There is

FIG. 20. CASE 21

Duration two years. Coxa valga after manipulation. Duration one year.

usually more or less atrophy and in cases of gross displacement there may be some necrosis. An unusual case is that of Kappis[40] with total necrosis of the bone, but firm union. Instances of necrosis of bone, marrow, and cartilage, such as that reported by Axhausen, in which there was a fracture of the neck of the femur in a boy of sixteen, apparently do not occur in epiphyseal coxa vara. This is probably because the periosteum behind and below the neck usually remains intact and attached to the head.

The acute symptoms always quiet down and as a rule these hips are free from pain except after an unusual amount of exercise. The shorten-

ing and the prominence of the trochanter persist and most of the patients develop a mild scoliosis with some slight structural change. These hips are always limited in internal rotation and abduction and are usually limited in flexion. In many of them there is permanent flexion with resultant lordosis. In some instances the hips are practically ankylosed, only a few degrees of motion being permitted in any direction.

All of these patients walk with a more or less pronounced limp and in many of them there is a positive Trendelenberg. They are handicapped in

FIG. 21. CASE 12
Duration three years.

sitting, stooping, and in putting on their shoes. The atrophy of the thigh and buttock persist and in many instances there is a noticeable weakness in the affected extremity.

The roentgenograms of the older cases show typical deformity in some instances, but often the neck is shortened on both upper and lower borders and the head enlarged and flattened to resemble an old case of Legg's disease. From what we now know of the influence of abnormal strain and faulty joint mechanics upon the development of hypertrophic or osteoarthritis it is probable that all of these patients who reach later

adult life will develop arthritic changes in the affected hip. A great many of the cases of malum coxae senilis are probably due to old epiphyseal coxa vara or to old Legg's disease (Figs. 19 to 25 inclusive).

In cases in which the epiphysis is replaced in its normal position the prognosis is, of course, much better. Wilson[32] has recently reported seven cases in which the epiphysis was replaced by open operation (his Case 1 is Case 10 in my series). In these cases there is at present little or no limp, no pain, and almost normal motion in the hip.

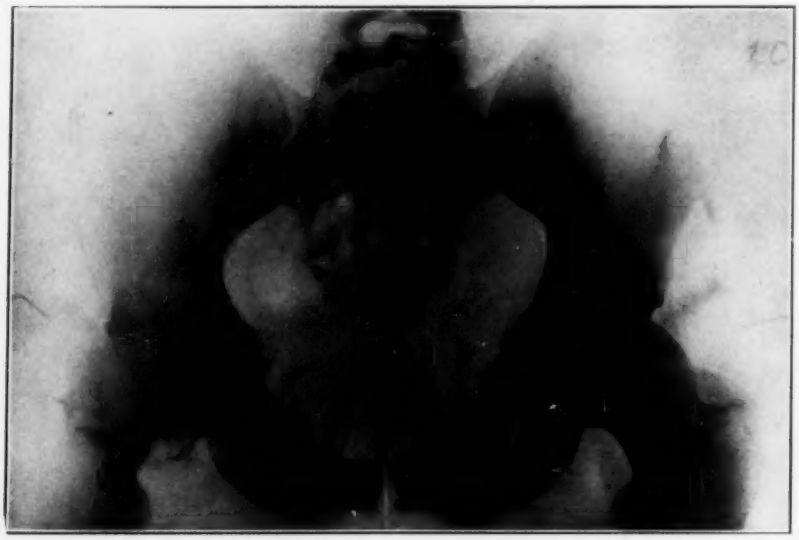

FIG. 22. CASE 20
Duration four years.

TREATMENT

The treatment of coxa vara is by no means standardized. The obvious thing to do is to replace the head upon the neck in its normal relationships and maintain it there until union is firm and there is no longer any danger of a recurrence of the deformity. The usual procedure both in this country and abroad (Whitman[23]; Lorenz[77]) is to attempt to reduce the deformity by manipulation under full anaesthesia or by prolonged traction in abduction and internal rotation (Sprengel[87]). The manipulation recommended by Whitman is forcible flexion and internal rotation followed by traction

and abduction of the thigh. After manipulation, the hip is fixed in the corrected position by a large plaster spica. After eight or twelve weeks the spica may be replaced by a walking splint, preferably of the Bradford abduction type.

Up to 1922 when this series of cases was reviewed the above was the standard method of treatment employed at the Massachusetts General Hospital. The results obtained by us have been reviewed under the prog-

FIG. 23. CASE 19
Duration six and one-half years.

nosis. In this day and time they cannot be considered anything but poor. The fault lies not in the execution of the manipulations but in the applicability of the method to the average case of epiphyseal coxa vara. In twenty-two of our cases (excluding the two adult cases in which the patients came to the clinic many years after the condition began) the average length of time from the onset of symptoms to the appearance of the patient in the clinic was 14.6 months. The earliest cases were admitted two months after the onset of symptoms.

We would regard it as absurd to endeavor to correct a malunion of a year's duration in a fracture of the femur in an adolescent by either manipulation or traction, yet because the lesion is in the epiphyseal line we have considered it a practicable procedure to manipulate the thigh and force the head back into its normal position. There are, of course, cases which can be cured by the manipulative method, but they are few and far between, at least from the standpoint of the orthopaedic surgeon. This is either

FIG. 24. CASE 16
Duration about fifteen years.

because they have not been seen by a physician or have not been correctly diagnosed until the epiphysis is firmly fixed in its new position.

As the anatomy of epiphyseal coxa vara varies from time to time and the condition is either slowly or rapidly progressive, the treatment should be adapted to fit the particular type of case with which one is dealing. For the purpose of treatment, epiphyseal coxa vara can be considered under five subdivisions as follows: (1) cases without displacement; (2) early cases; (3) advanced cases; (4) healed cases in young adults; and (5) old cases with arthritic changes in older adults.

(1) It has been emphasized that epiphyseal coxa vara is a condition of loosening of the epiphysis of gradual onset and that in certain instances it is possible to make the diagnosis before displacement of the epiphysis has occurred. In such cases the hip should be protected from the strain of weight-bearing by a Thomas ring or Bradford abduction splint. If the patient is overweight an obesity diet should be prescribed. Unless there are definite indications of endocrine disturbances I see no reason for using any glandular therapy, as there is no evidence as yet that the epiphyseal

FIG. 25. CASE 15
Duration thirty-three years.

weakening is a result of endocrine disturbance. As the condition continues to progress over periods varying from one to three years, the splint should be worn for at least a year, and then gradually discarded. During the second and third years after the onset the patient should be carefully watched and at the first reappearance of symptoms the splint should be reapplied. The general health and hygiene of the patient should, of course, receive attention. In these cases and in those of Groups II and III the uninvolved hip should be watched carefully, as in about one-fifth of the cases the condition becomes bilateral.

(2) Early cases. These cases are those in which the epiphysis is

practically normal in contour and is just beginning to slip or in which, due to a recent trauma (not as a rule over four weeks preceding the manipulation), the head has been grossly displaced on the femur. In these cases an attempt should be made to reduce the deformity by Whitman's procedure as outlined above. It is important that the reduction be complete, and anatomic restoration of the upper end of the femur secured, because in the hip physiological cure is secured by nothing less. For this reason it is necessary to check the result after manipulation by roentgenograms and to continue to check the result until adult life is reached and there is no longer danger of recurrence. If a roentgenogram taken with the patient in the plaster spica shows the head in its normal relationship to the neck, then the spica should be left on for ten weeks. At the end of this period the cast is removed and the patient encouraged to move the hip voluntarily in bed. At the end of a week or ten days a hip splint, preferably a Bradford abduction splint, is fitted to the patient and weight-bearing is begun. The splint is worn for about two months and then gradually discarded and normal use resumed. Massage, passive motion, and local heat may be helpful in restoring the function of the extremity but it is believed that the most important aid is voluntary motion. This is best done under the supervision of a skilled physiotherapist. Personally, for purely empirical reasons, cod liver oil is given during convalescence. Since Phemister has shown that phosphorus apparently hastens union in fractures, this is added to the cod liver oil. It is to be noted that after treatment there is freedom from weight-bearing for only four or five months while it was stated above that the condition continues to progress over a period of one to three years. This is because the separation and replacement of the head seem in some way to hasten or cure the process and cause the epiphysis to unite firmly to the neck again. In the literature I have seen only one case reported as having recurred after the epiphysis was definitely replaced. This was the case of Jouon[96,97] in a girl of fourteen who fell on the hip three months after reduction and slipped the epiphysis a second time. At least one roentgenogram should be taken during the period when the patient is wearing the splint and another should be taken after the splint is discarded and normal weight-bearing resumed. If the head has slipped again the treatment must be started from the beginning. I have seen the deformity progress with the patient in an abduction splint. These patients should be examined at least once a year until adult life is reached. If anatomic reposition is not obtained the procedure should be that as outlined for Group III.

(3) Advanced cases with a normal or fairly normal head. This group

includes the purely static cases in which the head is not separated but has slipped well down on the neck and is more or less deformed and sickle-shaped but still recognizable as a distinct mass of bone, separated from the neck by the irregular epiphyseal line. It also includes those so-called traumatic cases of more than six weeks' duration in which there has been gross displacement of the head following a trauma and in which it is seen to be hooked over the postero-inferior border of the mesial end of the neck. In these cases it is useless to attempt reduction by manipulation. Not only is the head firmly fixed in its new position on the neck, but owing to its position the sharp posterior inferior border of the neck is embedded in the concave cancellous tissue of the epiphyseal region of the head, while the smooth rounded cartilaginous surface of the head glides in the acetabulum. At the limits of abduction and internal rotation permitted, the head is locked against the postero-inferior portion of the capsule and acetabulum. If these movements are forced the neck is driven further into the cancellous tissue of the head. This is admirably illustrated in our Case 21, where the right leg was abducted fully to fix the pelvis, while the affected leg was forced into abduction. The slipped epiphysis was not appreciably moved, but the opposite epiphysis was torn loose and an epiphyseal coxa valga produced (Fig. 20).

It is to be pointed out that in these cases by forcible manipulation under anaesthesia, abduction and internal rotation of the limb can be obtained. But it does not mean anything because the capsule is simply stretched and the head is not replaced, but goes with the neck, and the deformity recurs shortly after the fixation is discontinued. Not only is this true, but from the results obtained in our series one is justified in suspecting that the trauma inflicted by the manipulation actually tends to increase the ultimate stiffening in the joint. It is obvious then that in these cases one must resort to open operation if a satisfactory result is to be obtained. The operation of choice is, I believe, to open the hip joint, free the head from the neck with a chisel, then replace the head on the neck, wash out the joint with salt solution, suture the capsule and close the wound, and fix the hip in a plaster spica in abduction, internal rotation, and slight extension. It may be necessary to remove a portion of the end of the neck in order to effect the reposition of the head. If the head is enlarged and overlaps the neck to any great extent its edges should be trimmed. Whitman,[98] who introduced this method, prefers the anterior approach to the joint. Wilson, in some recent cases, has found that the supero-lateral approach of Smith-Petersen[99] gives an admirable exposure.

(4) Healed cases in young adults with markedly deformed head and neck. These are cases in which the neck is thickened and convex above and has established a smooth bearing surface resting against the upper portion of the acetabulum. The head is in its typical location but is grossly deformed and the boundary between it and the neck is ill-defined. On examining the roentgenogram the surgeon is impressed by the fact that after he exposed the hip he probably would not know what to do next. It would be difficult to decide how much to take off, as the head, once freed, would probably be so deformed that it would make a very poor joint. It has been recommended that the thing to do is to chisel off the projecting upper and anterior border of the end of the neck. This was done in one of our cases[17] and the patient now has almost complete ankylosis of the hip and is one of our worst results. In these cases it is not possible to get an even approximately normal joint. The upper end of the neck is so rounded off that it offers a very efficient bearing surface if abduction and internal rotation be restored. Consequently, the operation of choice is osteotomy of the upper end of the femur followed by fixation in abduction, internal rotation, and extension. Osteotomy of the upper end of the femur for improving the function in the hip in coxa vara was first performed by Keetley[5] in 1888 and apparently forgotten and proposed as a new procedure by Kraske[100] in 1896. Since Kraske's paper, osteotomies have been done in the neck, trochanter region, and shaft. Wedge, linear, and curved osteotomies, and at various angles have been advocated by different surgeons. Whitman prefers a linear osteotomy of the shaft just below the trochanter minor in older subjects where the external rotation is marked. I am inclined to favor an osteotomy through the cancellous bone of the inter-trochanteric region done in the shape of an inverted V with a wedge removed from the outer limb to facilitate abduction. An equally efficient but more difficult operation to perform is curved osteotomy in this region as suggested by Brackett.[101] The curve is convex upward and the inner limb is prolonged downward. Either of these types renders displacement and slipping inward of the lower fragment less likely.

At the time of the osteotomy it may be necessary to cut the adductors, as was Keetley's experience, in order to obtain abduction. The after treatment is the same as in Groups II and III.

(5) In older patients with arthritic changes one should be more conservative. In 1905 Hofmeister[13] estimated that the mortality in operations for the correction of coxa vara was seven per cent. In our series only five cases were operated upon and in one of these the wound

became infected and the patient died. This, of course, was not to be expected in the usual course of events and ordinarily will not happen again for a long time.' It serves, however, to emphasize the fact that any operative procedure designed to correct a coxa vara is a serious operation and should not be lightly undertaken. We believe that well-trained surgeons in well-equipped hospitals can treat these cases operatively today with a mortality of about one to two per cent. We have, however, no adequate statistics to support our belief. Nevertheless, we recommend operative interference in Groups III and IV.

But the older patients are poor operative risks, especially as regards operations on the hip, and a very definite effort should be made to relieve the pain by rest, physiotherapy, general hygiene, and support to the joint before operation is even considered. If these efforts fail and the patient desires an operation, then the simplest and quickest procedure possible to relieve the condition and give a fairly serviceable hip should be done. Jones[102] does an osteotomy and produces a pseudoarthrosis in many cases similar to these. Another relatively simple procedure is the trimming down of the enlarged head and the removal of osteophytes from the margins of the acetabulum. In certain cases an inter-trochanteric osteotomy may be the best procedure. Arthrodesis should not be attempted as the eburnated bones seldom unite, and even disarticulation of the hip should be avoided in these older patients on account of its tendency to be followed by shock.

SUMMARY AND CONCLUSION

The history of the recognition of epiphyseal coxa vara as a definite clinical entity is sketched. The term coxa vara is defined and an anatomic and etiologic classification of the various types of coxa vara is given.

The incidence is given and the clinical picture and roentgenologic findings in epiphyseal coxa vara are described in detail. Twenty-four cases are reported.

The pathologic specimens reported in the literature are reviewed and discussed. The true pathology is unknown, as no early specimen has been described.

The various theories as to the etiology of the condition are critically reviewed and it is suggested that the condition is due to a weakening of the periosteum binding the head to the neck of the femur. The cause of this weakening is unknown, but it is usually coincident with a period of unusually rapid growth during adolescence.

The mechanics of epiphyseal coxa vara is discussed and the differential diagnosis is given. The end-results obtained in fourteen cases are discussed and these cases are reported in detail. In our experience the cases have all been seen some time after the onset of the condition and in such cases the prognosis without open operation is that of a hip usually somewhat painful and always limited in internal rotation and abduction and often limited in flexion. In many cases permanent flexion develops and persists. The hip may become practically ankylosed in severe cases. It is felt that forcible manipulation of an old case tends to result in increased stiffening of the hip and is not justified by the results obtained in our cases. The treatment of the condition in the various stages encountered in its natural evolution is given in detail.

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DISCUSSION

Dr. R. B. Osgood, Boston: This work stands for itself. It is exactly the kind of work we want if we are going to do intelligent joint surgery. It is this work that is going to make clinical work worth while. Without such work as this, clinical work is of little service.

END-RESULT STUDY OF ARTHRODESIS OF THE SACRO-ILIAC JOINT FOR ARTHRITIS—TRAUMATIC AND NON-TRAUMATIC

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It is the purpose of this paper to offer evidence justifying the diagnosis of traumatic arthritis of the sacro-iliac joint. This evidence will be offered in such a way that surgeons of the opposite viewpoint in order to refute it will have to do more than simply state "there is no such condition as traumatic sacro-iliac arthritis." There are a great many orthopaedic surgeons who hold this latter point of view in a passive, non-aggressive way.

DIAGNOSIS

Diagnosis depends on a careful history and examination; roentgenograms are corroborative evidence. Since our end-result study is based on the paper read before this Association a year ago, we will give here only an outline of it.

1. History:
   - *a.* Onset: Traumatic
     Non-Traumatic
   - *b.* Pain: Local Pain
     Radiation Pain
2. Examination:
   - *a.* Inspection: List
     Muscle Spasm
   - *b.* Palpation: Areas of tenderness
   - *c.* Motions: Standing
     Sitting
     Lying
   - *d.* Special Tests: Straight Leg Raising
     Compression of Iliac Crests
     Passive Lumbar Flexion

OPERATIVE TECHNIQUE

Since several important features of the operation have been changed since it was published in 1921, we will briefly describe the different steps:

FIG. 1

Incision along posterior two-thirds of the iliac crest, curving around the posterior superior spine, then running parallel with the fibers of the gluteus maximus for a distance of two to three inches.

ROENTGENOGRAPHIC INTERPRETATION

The points to be looked for under roentgenographic interpretation are: (1) Increased density along the margins of the joint; (2) Irregularity of the joint line; (3) Proliferative changes at the inferior margin of the joint; (4) Disalignment of the pubes.

Four of twenty-six cases, or 15.5%, had negative roentgenographic findings.

FIG. 2

Flap outlined by incision as described under Fig. 1, is reflected subperiosteally, exposing the lateral surface of the ilium. If the sacro-iliac joint is projected on the lateral surface of the ilium, it will be found that the inferior border corresponds to the sacro-sciatic notch, and the anterior border to the median gluteal line.

FIG. 3

With a motor driven saw a window is removed from the ilium; this window extends posteriorly into the inferior sacro-iliac ligament.

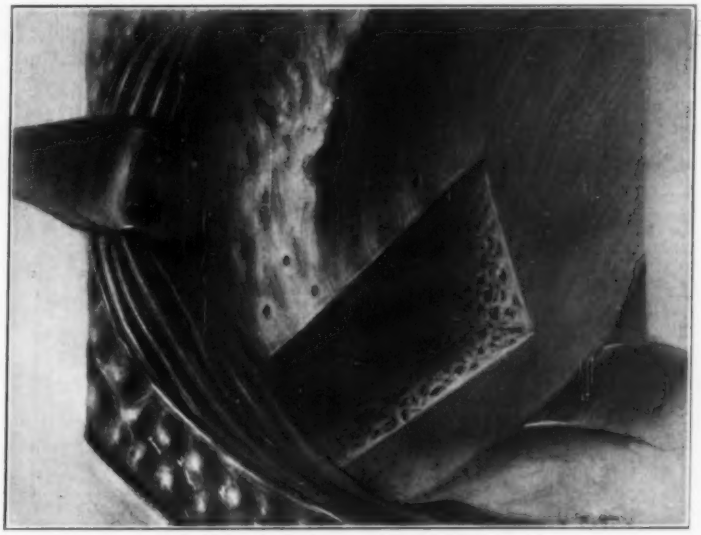


FIG. 4

Sacral joint surface is removed exposing cancellous bone; joint cartilage is curetted with angulated curettes.

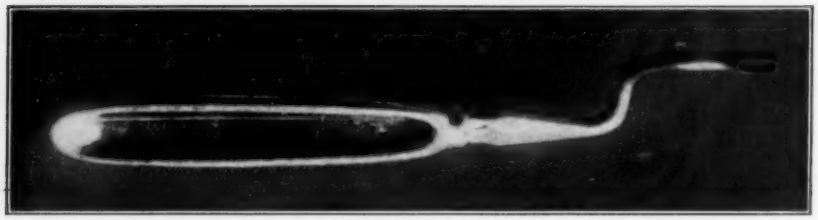


FIG. 5
Angulated curette.

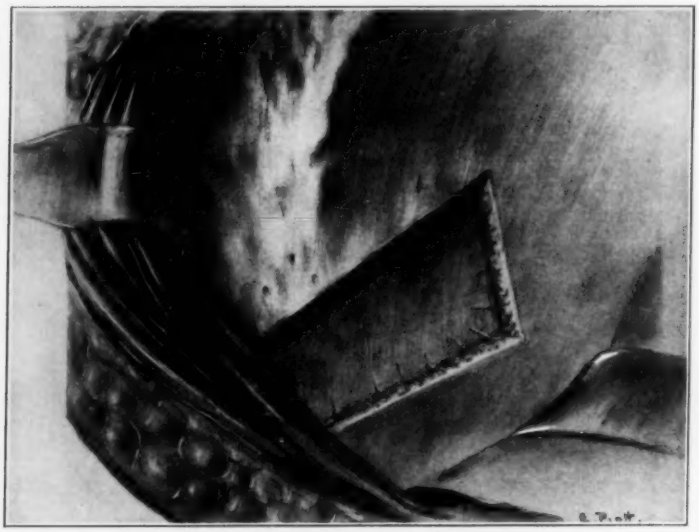


FIG. 6

After denuding the block of bone of cartilage, this same block is replaced and counter-sunk, so that its cancellous surface comes in contact with the cancellous bone of the sacrum.

Pre-Operative Roentgenographic Findings		
Increased Density Along Margins of Joint	12 of 19 cases	63%
Irregularity of Joint Line	10 of 19 cases	56%
Proliferative Changes at Inferior Margin of Joint	7 of 19 cases	33%
Disalignment of Pubes	5 of 19 cases	22%
Post-Operative Roentgenographic Findings		
Fusion	21 of 23 cases	95%

FIG. 7

In order to further secure the counter-sunk block, and also to promote osteogenesis, the edges of the window are osteotomized.

CYTOLOGICAL EXAMINATION

A mistake was made in the early operative cases in not having a microscopic examination performed of cartilage and bone removed when these tissues appeared normal on macroscopic examination. In the later cases, however, microscopic study has been undertaken, and in some cases definite changes have been found varying in degree.

The characteristic changes are:- 1. Erosion of the joint cartilage. 2. Replacement fibrosis, seen chiefly at the junction of the cartilage with

underlying bone, but also in the medullary spaces. 3. In some cases replacement fibrosis is so extensive that not a vestige of cartilage is found, the joint surfaces consisting entirely of fibrous scar tissue. 4. In some cases localized areas of hemorrhage with blood pigment were seen within the region of fibrosis.

SYMPTOM ANALYSIS

Pre-Operative Findings

Arthritis (Traumatic and Non-Traumatic)

Site of Local Pain..... Region of inferior sacro-iliac ligaments and sacro-sciatic notch

100% (26 of 26 cases)

Subjective Areas of Radiation Pain.....

(*a*) Posterior Aspect of Thigh
89% (23 of 26 cases)

(*b*) Posterior Aspect of Leg
81% (21 of 26 cases)

(*c*) Course of the Superior Gluteal Nerve
23% (6 of 26 cases)

(*d*) Lower Mesial Aspect of Thigh
12% (3 of 26 cases)

This table speaks for itself. We wish to emphasize the presence of local pain in the region of the inferior sacro-iliac ligament and sacro-sciatic notch—100% (26 out of 26 cases). Further, the almost constant finding of radiation pain along the distribution of the first and second sacral nerves, namely, the posterior aspect of the thigh, posterior and lateral aspects of the leg. That this distribution of pain is such a constant finding we attribute to the innervation of the sacro-iliac joint by these nerves.

Pre-Operative Findings

Inspection

Arthritis (Traumatic and Non-Traumatic)

List..... 72% (18 of 25 cases)

	Toward Lesion		*Away from Lesion*	
	8		10	
	Acute	*Subacute*	*Acute*	*Subacute*
	4	4	9	1

Spasm of Erector Spinae.... 74% (20 of 27 cases)

No definite conclusions can be drawn from this table except that it is interesting to note that the list was present in 72% of the cases. The cases in which there was no list were not acute at the time of the examination.

FIG. 8

Normal section of sacro-iliac joint. Normal cartilage and normal bone.

Muscle spasm was present in all acute cases in the standing position. This muscle spasm diminished or entirely disappeared in the sitting or lying position, as clearly demonstrated by the freedom of mobility of the lumbar spine (see Table 5).

FIG. 9

Section from sacro-iliac joint showing: (1) Erosion of joint cartilage; (2) Replacement fibrosis.

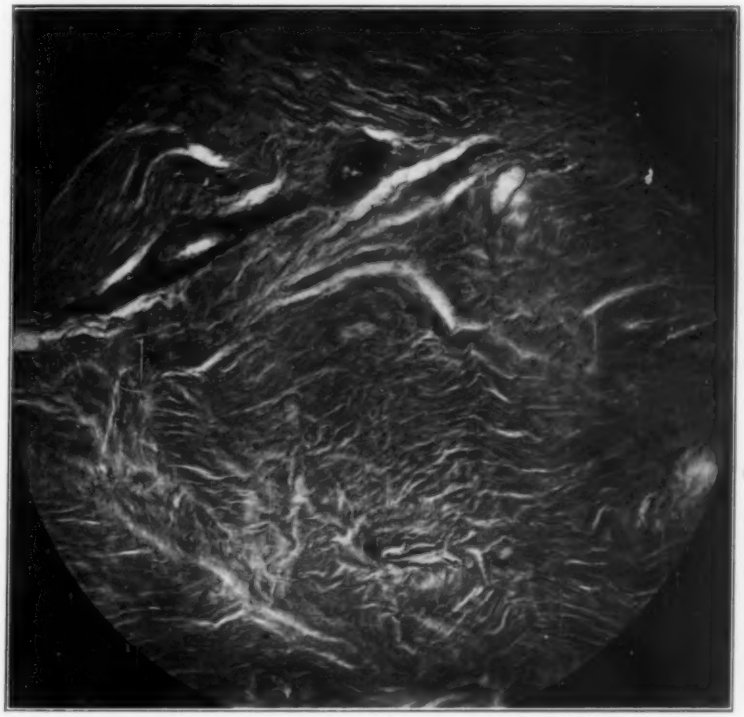


FIG. 10

Section from sacro-iliac joint showing complete replacement fibrosis.

Pre-Operative Findings
Continued

	Points of Tenderness on Palpation
Inferior Sacro-iliac Ligaments and Sacro-sciatic Notch	100% (26 of 26 cases)
Distribution of Superior Gluteal Nerve	23% (6 of 26 cases)
Sciatic Nerve Trunk	27% (7 of 26 cases)
Lumbo-sacral Region	3.9% (1 of 26 cases)

Again let us emphasize that on palpation the area of subjective local pain was found to be sensitive in 100% of the cases. Further, it is of great importance to note that lumbo-sacral tenderness was present in but one of the twenty-six cases, and this case was an extremely acute one with marked muscle spasm of the erector spinae muscles, of long duration. The tenderness in this case was attributed to this prolonged muscle spasm resulting in strain of the origin of the erector spinae muscles.

Pre-Operative Findings
Continued

Motions

Arthritis (Traumatic and Non-Traumatic)

Increased Range of Forward Bending Sitting over that Standing	71% (15 of 21 cases)
Average Increase	25°
No Aggravation of Pain on Forward Bending, Standing, or Sitting	13% (3 of 23 cases)
Normal Forward Bending Standing and Sitting but with Aggravation of Pain (Less Aggravation Sitting.)	11% (3 of 28 cases)

In 71% of the cases there was an increased range of flexion sitting over that standing, and the average increase was 25 degrees. We feel that the explanation for this finding is the elimination of hamstring leverage. It is very strong evidence against a lumbar or lumbo-sacral lesion.

Pre-Operative Findings

Continued

Special Tests

Arthritis (Traumatic and Non-Traumatic)

Passive Lumbar Flexion	
Over 145°	81% (21 of 26 cases)
Less than 145°	19% (5 of 26 cases)
Straight leg Raising	
Average Limitation of Affected Side when Present	31°
Average Limitation of unaffected Side when Present	9°
No Limitation on Affected Side, but Accompanied by Pain	12% (3 of 26 cases)
No Limitation on Opposite Side	50% (13 of 26 cases)
Average Difference Affected and Opposite Sides	22°
No Limitation or Pain	8% (2 of 26 cases)

Passive lumbar flexion invariably showed lumbar spine mobility. In all but five of the cases there was a range of motion of over 145 degrees. Those in which it was less than 145 degrees were found to be exquisitely sensitive in the region of the posterior superior spine and very acute generally. The pressure of the affected side against the table could not be tolerated.

The straight leg raising test was positive in twenty-four of the twenty-six cases. On the affected side this test showed either limitation or aggravation of pain, or both. On the unaffected side there is less limitation or aggravation.

Of the two cases that were negative, one has been classified as an operative failure and the other as a partial success only.

Special Tests

Arthritis (Traumatic and Non-Traumatic)

Lateral Compression of Iliac Crests Positive	52% (11 of 21 cases)
Rectal Examination Positive	100% (7 of 7 cases)
Pain on Hyperextension of Spine	50% (8 of 16 cases)

Lateral compression or heavy percussion was present in 52% of all our cases—a sign the textbooks feature as the outstanding symptom of a sacro-iliac lesion. Some orthopaedic surgeons go so far as to consider this sign pathognomonic of sacro-iliac conditions. We regard it as valuable when present, but even then often misleading, and not pathognomonic.

POST-OPERATIVE FINDINGS

In order to eliminate the personal element the examinations were made by one of us, who, with the exception of three cases in the twenty-six making up the series, had never seen the patients prior to their end-result examination.

Time and Occupational

Return to Previous Occupation	*Duration of Symptoms Pre-operative*	*Average time of Return to Light Activities*	*Full Activities*	*Average time at Full activities*
25 of 26 cases 96%	Average 14 mos. From 2 to 32 mos. Also cases of up to 10 years	2.6 mos.	4.5 mos.	13 mos.

It is to be noted that in 89% of the cases,—that is twenty-three of twenty-six,—there has been no pain since operation. Of the three remaining cases one showed a bilateral sacro-iliac traumatic arthritis. One side was operated upon and relief of radiation pain resulted. There is still local and radiation pain present on the other side. The other two complained of persistence of pain in the calf of the leg, but stated that this is far less than formerly, is decreasing, and they have resumed their former occupations in full.

It should be stated that seven of the twenty-six cases have shown a stiffness in either the calf or hamstring muscles, or both, for varying periods of two to six months after operation. These cases, it is interesting to note, were operated upon during a time when they showed severe local and radiation pain, and it is our opinion that this annoying symptom could be obviated by waiting until the pain had subsided.

END-RESULT STUDY

	Arthritis (Traumatic and Non-Traumatic)	
Complete Recovery.....	22 of 26 cases	84.6%
Partial Recovery.....	2 of 26 cases	7.7%
Failures.....	2 of 26 cases	7.7%

By complete recovery we mean absolute relief from symptoms, no limitation of activities, and return to former occupation; upon physical examination, negative findings, and finally bony fusion shown in the roentgenogram. In twenty-two of twenty-six cases included in this report such a result has been obtained. In two cases only a partial recovery has been achieved. One of these patients has not returned to her former occupation. Relieved from local and radiation pains, she still presents symptoms of faulty posture and ptosis. In the second case the diagnosis of bilateral traumatic sacro-iliac arthritis was made; one side was fused with relief from radiation pain; local pain persists, however. The other side still gives rise to symptoms. That there has been considerable improvement is shown by the fact that the patient has returned to his former occupation, for which he was completely disabled for two months before operation.

The results in two of the twenty-six cases are failures. One of these patients volunteers the following statement: "I am just the same as I was before the operation except for the pain down the back of my thigh and leg." She still complains of pain over the lateral aspect of the thigh. She has no points of tenderness except in the region of the scar, and the mobility of her spine is normal in all directions without aggravation of pain.

The other failure is in a case of spondylose rhizomélique starting in the sacro-iliac joint and giving rise to very acute symptoms. Operation gave complete relief from local symptoms, but the arthritis progressed, involving the entire spine, one hip, and one shoulder. From the patient's point of view the operation was a failure since it did not arrest the disease; from the surgeon's point of view the operation was a failure since nature would have fused the joint without operative interference.

CONCLUDING REMARKS

It has been the purpose of this paper to present the end-results of arthrodesis of the sacro-iliac joint, traumatic and non-traumatic in origin. These end-results, if favorable, would not only establish the operative procedure as a useful method of treatment, but they would also prove the soundness of the method of differential diagnosis. If the analysis of signs and symptoms, or, in other words, the method of localizing the lesion were incorrect, operative treatment would be ineffective. The end-result table shows a very high percentage of successful cases, consequently we feel justified in concluding that the diagnosis as well as the treatment has been correct.

DISCUSSION

Dr. R. B. Osgood, Boston: I am very sorry indeed that Dr. Baer could not be here to open the discussion. I think we are extraordinarily fortunate in having this very fine piece of work presented to us. It gives ample opportunity for discussion and perhaps for some conclusions because it illustrates my own change of conception. Dr. Adams will recall a patient left in my charge when he went on his vacation some time ago. The man had pain of the type Dr. Smith-Petersen described. Dr. Adams had started to treat him by immobilization and I continued his plan. Then I went away on vacation and the patient had a return of his pain on the resumption of activities. Dr. Smith-Petersen then took charge of the case and operated upon the patient's joint. I was rather shocked when I learned of this, but found the patient had stood the operation very well and has been perfectly well ever since, and that is now two or three years.

I have watched these cases, starting with the opinion that this was rather radical surgery and that we were getting most of our cases well without it, and perhaps we *are* getting many of them well. I have come to the conclusion that this piece of work represents in its present stage not radical, but conservative, surgery. In these cases not a single death has occurred as a direct result of the operation. The shock, as Dr. Smith-Petersen performs the operation, is extraordinarily slight. The immobilization, which he did not mention, is practically nothing. A binder is put on and the patient stays in bed. I believe the results of the cases are such as Dr. Smith-Petersen and Dr. Rogers have shown. According to the analysis which Dr. Smith-Petersen and Dr. Rogers have made, we must accept it absolutely at its face value; that is, that we have a new method of controlling low back pain in a type of case that has been to us at times very obstinate.

One word in relation to the list. Dr. Smith-Petersen said that the list in half the cases, eight to ten, was to one side and in the other half, to the other side. I have the impression perhaps that after he has followed this up he will find that the explanation of this list being sometimes to one side and again to the other might be a deviation of the lumbar vertebrae to one side which may result in a single curve to the same side or a double curve which would make the gross deviation appear to the other side.

I am allowed by Dr. Smith-Petersen to say that his wife had this condition and was treated by the best orthopaedic talent we have in Boston, but did not become permanently well. Dr. Smith-Petersen was quite convinced that her lesion was in the sacro-iliac joint and we had a long discussion as to who would perform the operation on her. I told him that he was the man to do this operation. He did and after years of invalidism she is about the healthiest person in Boston.

Dr. M. H. Rogers, Boston: I have watched this work go on for the last seven years and I am absolutely convinced that in certain selected cases there is a definite value for arthrodesis in sacro-iliac joints. I think as we go on we will select our cases a little earlier in the symptomatology than we have been doing. I think if we can convince ourselves that this is a recurrent condition, that it is moderately severe, and that it is in the sacro-iliac joint, we will be apt to perform this operation more rather than less in the future.

Dr. F. J. Gaenslen, Milwaukee, Wis.: The subject of sacro-iliac arthrodesis has interested me for a number of years and I am sure that we all feel much indebted to Dr. Smith-Petersen for the painstaking work which he has done in following up and

reporting on this group of cases. His series is unusually large because these cases are apt to drift to him by reason of his continued interest and effort in this particular field.

My own series is much smaller. In a total of six, the diagnosis was tuberculosis in three and relaxation in three. One of the latter followed a severe crushing injury.

My own technique, described in the Wisconsin State Medical Journal, July, 1921, differs somewhat from that of Dr. Smith-Petersen. The incision is made just above the posterior two-thirds of the iliac crest and extending well down past the posterior inferior spine. The posterior portion of the ilium is then split flatwise into an inner and an outer leaf and a large flap consisting of skin, muscle, and the outer leaf of ilium is deflected outward. With a chisel the medial portion of the ilium overlying the joint is removed, exposing the sacro-iliac joint. The latter is completely destroyed, the resulting bone defect being filled with healthy bone fragments. Closure is accomplished by turning the large flap upward into place and suture in layers.

The approach to this joint has always been difficult, but with such comprehensive reports and encouraging results as reported by Dr. Smith-Petersen at hand we may all feel encouraged to attack this joint surgically when indicated.

Dr. Z. B. Adams, Boston: I was very much interested last year in the paper that was read by Dr. Danforth and Dr. Wilson and I hope that Dr. Danforth will discuss this paper. I have done some work in the Anatomical Department on sacro-iliac joints and there are just two or three things I would like to mention. In splitting the pelvis and splitting the symphysis and then cutting the anterior sacro-iliac ligaments, you can spread the sacro-iliac joint on the front about half an inch without putting any tension on the nerves that run down across it. I think that this is a fact that ought to be taken into consideration when we talk of sciatic pain as a symptom of sacro-iliac derangement. Sciatic symptoms are not usual in fractures near the sacro-iliac joints. Another thing is that the sacro-iliac joint and the lumbosacral joints are very close together and any motion in the sacro-iliac joint produces motion in the lumbosacral joints. Then there are two or three other facts which I think should be brought out. One is, as I think you will agree, that in tuberculosis of the sacro-iliac joint there may be a destruction of the joint and the patient will have no sciatica at any time. That is only one of Dr. Smith-Petersen's diagnostic points, but there is another one, which is, that not uncommonly in post-gonorrheal fusion of the sacro-iliac joint the joints may be fused on both sides and the patient will have no sciatica at any time in either leg during the disease.

Dr. E. G. Brackett, Boston: I believe that in Boston we all practically advocate this operation, certainly in the selected cases. A great argument in favor of this procedure is found in the condition seen in museum specimens of this area of the skeleton, which show, and which corroborate the X-ray findings, that the long continued irritation of this joint, as in others, results in the attempt of nature, more or less complete, to ankylose this joint, and many times it is found that nature has gone very far to this end. Therefore, in carrying out this treatment, we are merely following nature's methods, anticipating frequently by many years her end result, and therefore saving the patient a long period of discomfort and often disability. Therefore, it is difficult to see how an argument could be raised against the operation as a procedure. I believe that frequently it is difficult to determine when it should best be done, whether early or whether to wait to determine whether nature will do her own part in this work, for certainly she corrects a large number of these spines. We also know that the majority of cases, even though the attacks may be repeated many times, entirely recover, or at

least recover and remain free from symptoms for quite a number of years. When the attacks are repeated with more or less increasing frequency and increased severity, it would seem that decision between the two procedures, operative and conservative, would not be difficult to make, yet it is a decision to be made by the patient, who will weigh in his own estimate the balance of inconvenience between the operation on one hand, and the inconvenience of the periods of disability on the other. Many times if the disability is not great the patient prefers this conservative method to the inconvenience and temporary disability following the operation. I believe that as a rule we should insist that the patient make this decision himself, for this type cannot be classed in the same group nor should our advice be given in quite the same way as in acute surgical procedures, where life might be endangered by delay.

There is one type of case difficult to distinguish between the lumbo-sacral and the sacro-iliac conditions, and I wish that in closing the discussion, Dr. Smith-Petersen would dwell a little on the diagnosis as well as the method of treatment. Many times the diagnosis between these two is clear, but many times it becomes one of the most difficult diagnoses which we have to make. This is particularly so, I believe, in those cases in which there is a certain amount of arthritic change in that area of the spine and which are apt to involve both regions to a certain extent, although not always equally, and the question arises as to which joint the symptoms are mainly due, and which we shall attack in the operation if undertaken. This is particularly so in those cases, so frequent, in which the lumbo-sacral area presents one of the many varieties of anatomic variations.

Dr. Nathaniel Allison, Boston: After the remarks of Dr. Osgood on Dr. Smith-Petersen's work I can add very little. I feel as Dr. Osgood does, that here we have a complete piece of work. Dr. Smith-Petersen presents diagnosis and treatment complete. When I first became associated with Dr. Smith-Petersen at the Massachusetts General Hospital I knew very little about this subject. I know very little about it now, but I have learned vastly from him in regard to the diagnosis of these cases, and one point in diagnosis I would like to emphasize: the importance of a careful physical examination. I think there is entirely too much importance given to a study of the X-ray plates in these cases. Dr. Adams has told you that if you cut the symphysis you may spread the sacro-iliac a half inch without affecting the nerves. We look at the X-ray picture and are inclined to say, "Yes, this joint is spread: here is a case of sacro-iliac arthritis." The roentgenogram may be thrown aside. We are not dealing in these cases with mechanical things; we are dealing, as Dr. Smith-Petersen has shown, with an arthritis. In the sections of these joints that were r ·ved, which he has shown you, the cartilage of the sacro-iliac joint is destr· ·eplaced by fibrous tissue. Nature has started on a plan of ankylosis wh· ·perfectly carried out. The situation is similar to that of an arthritis of the h· ·e cartilage is destroyed and where the head of the femur becomes eburnated and there is limited motion in the hip. It is on that fact that diagnosis should depend rather than on the X-ray photographs. Dr. Smith-Petersen has shown how to go about this in a systematic way, how to examine these people and how to find out whether they have or have not an arthritis in the sacro-iliac articulation. If they have such an arthritis, what is the length of time it will take to recover from it? By this simple procedure, which is the best that has been advised, the safest and the easiest done, this type of arthritis may be permanently cured.

Dr. M. S. Danforth, Providence, R. I.: I think we are to be very much congrat-

ulated on this piece of work by Dr. Smith-Petersen. I feel that the real point of it all is the diagnosis. The question of whether low back pain associated with leg pain or without leg pain is due to a lumbo-sacral or a sacro-iliac lesion is what is most necessary for us to solve.

In the work that Dr. Wilson and I did, I began with the idea that leg pain was usually due to trouble in the sacro-iliac joint. With that idea in mind I did some dissections; then I was joined by Dr. Wilson, who also thought the lesion was usually sacro-iliac. From our dissections, however, it seemed to us that it was probable that the irritation of the sciatic nerve was more likely to be caused by changes around the lumbo-sacral than around the sacro-iliac joint. We did not believe that there were no cases of sacro-iliac disease which caused pain. I think the difficulty that many of us have, and that I have, is to differentiate between lumbo-sacral lesions and sacro-iliac lesions. Certainly the character of Dr. Smith-Petersen's cases positively proves by the X-ray as well as by other signs that the trouble may be in the sacro-iliac joint. I believe the results of his operative work in fusion of the sacro-iliac joint prove conclusively that the trouble in his group of cases must be in the sacro-iliac joint, but there are many cases, however, in which I cannot be convinced that the trouble is in the sacro-iliac joint and not in the lumbo-sacral. Certainly we see changes in the sacro-iliac joint without leg pain and we get cases in which there is marked change shown by the roentgenogram also without pain. Perhaps there is enough fusion in these joints so that the pain has stopped.

I believe that every piece of work like this that is carefully carried out will help to get us to the point where we can make a reasonably positive diagnosis.

Dr. C. A. Stone, St. Louis: I do not know how many of you have had the same thing, but perhaps it might be well for me to tell you something. I am satisfied that I had a sacro-iliac on the left side and a lumbo-sacral on the right side. If you have had the same thing perhaps you will learn something about making the diagnosis of the two lesions. For ten years I suffered with a definite sacro-iliac on the left side. Three years ago in lifting, I hurt my back, and a couple of months later the roentgenogram showed a definite lesion in the lumbo-sacral articulation on the right side. I want to tell you that the two pains are absolutely and distinctly different. There is no comparison between them. The sacro-iliac on the left side is a pain that goes down the sciatic nerve posteriorly to the ankle and I believe is a referred pain, as Dr. Smith-Petersen said. The lumbo-sacral pain is a localized, distinct pain in the region of that articulation with a definite muscle spasm and severe pain on motion that is not characteristic of this other pain. The lumbo-sacral pain is not a referred pain.

Dr. M. N. Smith-Petersen, Boston (closing the discussion): Dr. Osgood referred to the postoperative treatment in his discussion. It consisted at first of a double plaster spica. Now it has been changed and consists in an abdominal binder while the patient is in bed. The patient stays in bed three weeks with the abdominal binder only. At the end of three weeks the patient is allowed up and about, wearing a sacro-iliac belt with a pad over each gluteal region in order to have increasing leverage. Patient leaves the hospital four weeks from the day of operation.

Dr. Adams spoke about the innervation of the joint and the anatomic relationship; also about tuberculosis and gonorrheal arthritis in giving referred pain. Tuberculosis is a constructive condition as well as a destructive condition. There is a fibrous ankylosis going hand in hand with a destructive condition and consequently there is an arthrodesis performed by nature in some of these cases while the tuberculous lesion is

still progressing, and consequently there is no referred pain in these cases. There may be a psoas abscess only. Nature is doing the work for us. Among our tuberculous cases, of which we had thirteen, ten had referred pain and three did not. In gonorrheal arthritis, which is chronic and slowly advancing, the patient is able to keep on working. Then there is a gonorrheal arthritis which is painful and rapidly progressing. In this latter acute type there is invariably referred pain. In the chronic, slowly progressing, there is no referred pain.

In order to test our end-results, we have three industrial cases in this series; one was a longshoreman, one was a dairyman whose work was rather heavy, and the other was a pick and shovel artist. The longshoreman has not gone back to his original work, but is doing heavy work. The dairyman and the pick and shovel man have gone back to their original work.

As to the time of operation, when I see a case I never suggest operation at the first sitting. With a man who is doing heavy manual work, in order to insure him against a recurrence, operation is advised. If the patient responds to the use of the sacro-iliac belt then there is not much need of an operation. If he does not respond in two months, operation should be considered. If there is a unilateral transverse process there is increased stability on one side and on the other side instability.

I am not by any means interpreting low back pain as sacro-iliac. I feel there are many lumbo-sacrals. Dr. Cook's therapeutic tests are helpful.

I have had the rare opportunity of having Dr. L. B. Morrison of Boston take many of these roentgenograms. He never knows what I am looking for. His diagnosis comes back in the majority of cases naming the same joint as we have picked by our physical examination. The X-ray should be used purely as corroborative evidence, not for making the diagnosis.

Dr. Danforth spoke about referred pain. I do not see how a lumbo-sacral lesion will give pain referred along the second sacral. In tuberculosis of the hip there is very often referred pain to the knee. It is not because of pressure on the nerve, but it is because of the innervation of the two joints from the same source. The same is true of the lumbo-sacral and sacro-iliac joints. In lumbo-sacral conditions there may be referred pain along the fifth lumbar and first sacral, i.e. anterior aspect of the leg and dorsum of the foot. You do not get posterior thigh pain, which is second sacral distribution. Posterior thigh pain is the most constant referred pain that we have to deal with in sacroiliac cases. When you see a patient with low back pain, no posterior thigh pain, but pain referred below the knee, I should be most suspicious of a lumbo-sacral condition.

SYSTEMATIC DIAGNOSIS IN BACKACHE

BY EDWARD T. WENTWORTH, M.D., ROCHESTER, N. Y.

Chief consideration is given in this paper to differential diagnosis of four types of traumatic back (sacro-iliac strain, sacro-iliac subluxation, lumbo-sacral strain, fractures and dislocations in the lumbo-sacral region); to static backs, often in those physically unfit for the over-stress of life; and to osteoarthritic backs.

Omitting lesions of the genito-urinary tract, the peritoneal cavity, and the intestinal tract, there are other conditions immune from the stigma of any popular diagnosis which are occasional causes of low back pain. Syphilis, tuberculosis, malignancies, rachialgia, gluteal myositis, gluteal bursitis, calcareous degeneration of the lumbar aorta, sclerosis of the blood vessels supplying the posterior ganglia, meningeal hemorrhage, epi- and intra-dural varices, calcareous deposits on the surface of the spinal dura, infection of retro-peritoneal lymph glands, and traumatic neurosis, have all been found as the cause of low back pain.

We are in a position to approach this subject without prejudice for any particular diagnosis, but with zeal to determine, in each individual patient, which one or combination of lesions is to be treated to secure relief from distress or disability. The purpose of this paper is to set forth a method of diagnosis. A large percentage of writers on low back pain state the incompleteness of our knowledge regarding what has happened when a back aches.*

Physicians in general are too prone to make a diagnosis, then to look for corroborative findings: *e.g.*, if tenderness can be found in the region of the sacro-iliac joint, the patient has a sacro-iliac strain. But such methods, no matter how renowned the user, do not make progress. Preconceived ideas of pathology must be eliminated from the process of making a diagnosis.

*J. R. Kuth[1] concludes from a study of 208 cases that, "Any injury or disease affecting the lower back structure (muscular, ligamentous, bursal, osseous, or joint), may give rise to a *similar symptom complex* in cases of chronic low back pain."

G. G. Davis[2] said, "Our knowledge of the anatomical lesions causing backache is so limited that any attempted explanation of cause and effect must be largely theoretical, even though we do our best to make it rational."

Ansel G. Cook and Gaenslen have both gone on record as treating the case first and diagnosing it later, utilizing the therapeutic test as their main diagnostic procedure.

Lawyers and judges appear to have a pretty generally formed opinion that a doctor's statement concerning disability of the lower back is largely a matter of guesswork. Elimination of guesswork, or what the lawyer ironically calls "opinion," is the purpose in setting forth the method of diagnosis.

A real low back case presents objective signs of localized tenderness, limited mobility, spasms, atrophies, pain characteristic of certain stresses, and radiographic findings sufficient to enable us to make a correct diagnosis almost always, and a satisfactory working diagnosis always.

The first act of the diagnostician should be to get well in mind the complaint,—the condition from which the sufferer seeks relief. Pain is the principal complaint. Localized pain or tenderness is very good evidence of local injury. Of course, patients usually expect tenderness where they have pain. Although nerves do not enter cartilage, they do exist in ligaments, fibrous structures, muscles, and periosteum. Traumatism to and around these structures, therefore, gives rise to pain. Pain is also produced by irritation or injury of nerve roots, of a nerve trunk, or nerve end-organ.

Pain may be constant, in which instance one leans very heavily on what the sufferer says about it. In some acute cases protective spasm prevents most of the discriminatory tests. Then location of the spontaneous sensations of pain, numbness, tingling, position of the part, and idea of the part, become of paramount importance.

Aside from local pain there may be radiations along the definite course of nerves, and into definite nerve areas; or there may be radiations into regions not anatomically bounded by nerves, that is, into regions designated by the imagination or by the wish, rather than by observation. This is important information.

There may be areas of reflex hyperalgesias, "sore spots," as the patient terms them. There are only nine such spots on the lower extremity including the buttocks, according to the charts of Dejerine,[3] representing reflex zones of the twelfth dorsal, first and fifth lumbar, first, second, third, and fourth sacral root segments.

If the pain is constant, it is very likely aggravated by certain conditions. If it is not constant, but intermittent, it is certainly brought on by certain conditions. The determination of painful stresses has always been considered a very valuable procedure, because by it one has opportunity not only to actually determine what stresses and, to some degree, what amount of stress causes pain, but also to check the patient's statement of what stress and what amount of stress causes pain.

A complaint of weakness is not easy to verify. But by measuring the range of motion, both with the patient under direct examination and under indirect examination, and by utilizing repeated and rather prolonged observations in the medical gymnasium, one can gain convincing information concerning limited motion and positive information on alleged weakness.

The next act of the diagnostician, after getting well in mind the complaint, should be to arrive at a definite opinion concerning the character or personality of the individual being studied. The economic and social backgrounds in which the patient, as a sufferer, exists, the mental attitude of the patient towards society and the emotional expression of fear, as well as the physical condition of the patient, should be recognized in arriving at a just decision regarding the character or personality of the patient. Any attempt to diagnose a case with complaint of low back pain, without recognition of the personality of the individual, is a blind attempt at diagnosis. There are often many conditions outside of the back, and even outside the individual, which make a back ache.

Most persons who have pain in the lower back present some objective evidence to corroborate it. There are undoubtedly some neurotics and malingerers in this field, just as there are in every field of medicine. Perhaps the lower back, because of its exceedingly complicated structural arrangement, is an unusually fertile field for malingering. We, who are constantly working in this field, are apt to feel that such is the case; but every field of physical study has its derelicts. Exaggeration is very common,—just as common as pure malingering is rare. Exaggeration is the natural defensive mechanism of one who fears he presents inadequate external evidence of pain which he feels. The "nervousness" encountered so often in compensation and public liability cases is an expression of the same emotion of fear, rather than physical injury. Before declaring a patient who complains of pain in the back to be either a neurotic or malingerer, we must observe that patient very carefully for some little time.

The second section of this paper is a brief discussion of the clinical entities in low back pain.

Fractures and Dislocations. Fractures and dislocations cause pain in this region, just as in all others, and for the same reasons.

Osteoarthritis. We believe that the bone changes called proliferative, hypertrophic, or rheumatoid arthritis, and arthritis deformans, in spines of laboring men are caused by the long continued stress of labor, plus an element arising out of bad hygiene (poor mouth hygiene, incorrect

kind and quantity of food, poor elimination, and possibly improper protection against the elements).* These changes certainly often cause no symptoms, except loss of motion, over long periods of time. Clinical experience is that in the vast majority of cases it is an injury which brings to light the presence of hypertrophic changes in the spine. Apparently individuals can live and work for years in the presence of slowly developing osteoarthritic changes without inconvenience.

Hypertrophic changes cause pain locally on motion and stress; radiating pain by irritation of nerve trunks where they pass through the spinal canal and where they cross the sacro-iliac joint, and referred pain along the course of other portions of nerves supplying involved joints. The radiographic picture of osteoarthritis is certainly only a part of the disease process. The soft tissue swelling about the calcareous deposit is probably usually the cause of distressing tension and direct pressure upon the nerves.

Sacro-Iliac Strain. Ligamentous strains, on the whole, are the result of one of two causes: muscle fatigue to the extent that support is no longer given by the muscles to the bony parts, or sudden over-exertion of muscles. In the first instance, long standing, stooping, or lying in a fixed position, particularly if this position is mechanically bad, results in sufficient muscle fatigue to throw all of the support of the bony parts upon the ligaments. In the second instance, any activity throwing excessive stress upon the musculature will strain the ligaments. Sudden excessive stress, after muscles have become fatigued from prolonged use or prolonged slight strain, is the most frequent condition under which ruptures of ligaments are sustained.

Ligaments, here as elsewhere, are inelastic, and when the limit of strength is reached, they rupture, and after rupture unite very slowly. Ruptures vary all the way from stretching, with minute areas of torn fibers, to gross tears. The length of time necessary for union following such lesions is commensurate with their severity and lack of protection. Cases of minute tearing of fibers, if unprotected, sustain reinjury of a sim-

* Whitman[4] reports that in 200 autopsies these changes were present in 60% of those over 40 years of age and in 100% of those over 50 years of age. These figures may be too high to be universal. They at least show the prevalence of hypertrophic changes associated with age and hard labor.

George and Leonard[5] speak of the vertebrae growing older, just as the arteries and the rest of the body. All laboring men who have done heavy lifting and pushing of heavy objects begin to have hypertrophic changes in the lumbar spine after 40 years of age. They have noted that these changes appear in the lateral view on the anterior borders of the bodies with greater frequency than in the antero-posterior view on the sides of the bodies.

Sacro-iliac obliteration, as described by Woldenberg[6] and by Blaine,[7] is only the end-result of osteoarthritis, probably what Goldthwait calls atrophic arthritis.

ilar character, until a condition of chronic relaxation or chronic fibrositis exists. These are extremely slow in recovery from symptoms.

It is not always wise or necessary to designate precisely by name what particular ligament is injured in a strained back. In fact, it is usually impossible. Most cases of strain of the sacro-iliac ligaments have also some strain of the lumbo-sacral ligaments and the lumbo-iliac ligaments.

The sacrum is wider at the anterior edge of the articular surface than it is at the posterior edge. In an upright position the base of the sacrum projects forward beyond the articular surfaces of the ilium and has a tendency to tip down. This is prevented by the sacro-iliac ligaments which hold the upper part of the sacrum back to the posterior projection of the ilium and by the sacro-sciatic ligaments which hold the lower part of the sacrum forward to the ischium.

Because stability of the sacro-iliac joints is so greatly dependent upon ligaments, these great articulations placed at the junction of the body and the lower extremities are mechanically weak to sustain the heavy stress thrown upon them, especially of backward or forward tilting of the base of the sacrum.

Sacro-Iliac Subluxation. The so-called subluxation of the sacro-iliac joints is greatly misunderstood. It is only because of the coincidence of symptoms with cases of demonstrable mobility at these joints and the relief of symptoms by a definite change in position at these joints, that subluxation is a good and proper diagnosis. The cartilaginous surfaces of the sacrum and the contiguous auricles of the ilia are unlike any other joint surfaces, in that they are very rough. This roughness greatly limits motion. When the ilia are normally held impinged against the sacrum there is a minimum of motion. The bone surfaces are, however, more or less covered by articular cartilage and there is a normal antero-posterior motion on a horizontal, transverse axis at the third sacral segment. A backward tilting of the base of the sacrum separates the ilia.

Relaxations of these articulations occur physiologically at the menses and during pregnancy. They occur also as the result of general debility and postural strain. Under the condition of subluxation, there is rarely a frank separation of the apposing articular surfaces, but the small irregularities on the surfaces are changed enough to disturb their normal relationship, with corresponding disturbance in sensation and function. The particular displacement most often seen following traumatic stress is a backward movement of the base of the sacrum. This is predominantly found in males and is the flat back type of deformity. The type in which the base of the sacrum is forward is usually the result of muscular weak-

ness. It is predominantly found in women, the adipose, neurotics, paralytics, and the generally debilitated. These bone slippings may cause irritation of the lumbar plexus, by bone pressure, by the pressure of exudate, and by nerve stretching. The sciatic cords cross directly over the middle of the sacro-iliac joint, lying upon the ligaments directly and in close apposition.

Displacements of normal bone juxtaposition of the sacrum probably do not often occur. Ridlon and Hibbs are firm in this conviction. In fact, they say they have never seen one. Certainly these authorities have no reference to gross displacements from severe trauma, for there are numerous recorded instances of such.[8,9] The writer has seen three such cases, with completely convincing radiographic evidence of the dislocation.

The disagreement concerning sacro-iliac subluxation is over the alleged "*catching*" of the joint in that amount of displacement which does not show in a good stereoscopic radiograph. The irregular conformation of the joint surfaces makes such a lesion theoretically quite possible. There is no question but that normally some little motion does take place and that under extreme stress a large amount of motion can occur,—enough to be radiographically demonstrated and to warrant the nomenclature of dislocation. Certainly, there is opportunity for various degrees of ligamentous stress between that checking normal motion and that permitting such extreme laceration that the bones are torn apart. Those who do not accept the lesion of subluxation do accept the lesion of sprain of the sacro-iliac joints.

But aside from the very plausible theoretical possibility of such a lesion, actual experience is convincing. All of us have had patients describe a sudden onset of severe pain with symptoms and signs well localized in one sacro-iliac joint, as a result of some sudden stress upon the joint, and of equally sudden and complete relief from that pain following some other stress, either therapeutically applied or unexpectedly accomplished by the patient himself.

All surgeons who practise manipulation have had the experience of accomplishing this relief during manipulation, with or without anesthesia,—not such manipulation under deep anesthesia as Baer carries out, but much less strenuous stress applied by straight leg raising or thigh hyperextension, and accompanied by an audible snap.

The proof of the diagnosis of sacro-iliac subluxation is the relief of symptoms by manipulative reduction of the subluxation.

Lumbo-Sacral Strain. A certain amount of lumbo-sacral strain is usually present accompanying a traumatic sacro-iliac strain. In a large

percentage of cases of low back strain, there is a factor of static lumbo-sacral strain due to lordotic posture and to congenital bone anomalies.

This joint is strikingly weak from the mechanical standpoint. In 1911 Goldthwait[10] clearly pointed out the mechanics of this joint. The plane between the body of the fifth lumbar and the base of the sacrum inclines thirty degrees with the body erect. The ligaments give considerable support, but if acting alone they would soon stretch. It is the articular processes which prevent a spondylolisthesis. One-half of the flexion and extension of the lumbar region takes place at the lumbo-sacral juncture, in part by changes in the intervertebral disc, but largely by an upward sliding of the articular processes of the fifth lumbar upon those of the first sacral.

Von Lackum's[11] recent series of dissections shows the average angle between the plane of the lumbo-sacral juncture and the horizontal, to be 42½ degrees, varying from 28 to 80. Whatever the angle may be, there is a very considerable shearing stress of the superimposed body weight as it is transmitted to the pelvis at this juncture.

This juncture is also the union of the mobile spine and the immobile sacrum and is consequently a weak mechanical arrangement. Augmenting this weakness is the usual greater amount of rotation at the lumbo-sacral than at the inter-lumbar articular facets. This is made possible by the unilateral or bilateral change from the normal lumbar internal-external articular facets to the horizontal or anterior-posterior form. It must be remembered that the pivot of motion is not at the articular facets but in the bodies of the vertebrae. The dorsal and sacral type permits free rotation, but limits extension. The lumbar type limits rotation, but permits flexion, extension, and lateral bending.

Spondylolisthesis does occur. It is clinically only the extreme of lumbo-sacral strain. It is much more apt to occur following trauma in the presence of the lumbar type of articular facets than the dorsal type, where a dislocation or fracture is necessary for the facet of the fifth lumbar to get by the sacral facet. Cases occurring without severe trauma are in the presence of anomalies, usually failure of fusion between pedicles and articular processes.

Goldthwait, by postural correction of exaggerated lumbar lordosis, and Hibbs, by fusion of the fifth lumbar to the sacrum, in order to transfer the junction of the immobile sacrum with the mobile spine upward to a point where the mechanics are more stable, are both striving toward the same end, namely, eradication of lumbo-sacral strain. The unsatisfactory mechanical situation at the lumbo-sacral juncture appears to be under the slow attention of nature, and may, in the course of aeons, be corrected by

adding one segment of the spine to the sacrum at the expense of the lumbar region.

Static Backache. The pain due to purely static imperfections, that is, the chronic strains due to improper poise of the feet, legs, pelvis, and spine, constitutes a story by itself,—the story of posture. Discussion of such disabilities is entered here only as they influence other lesions.

Congenital Anomalies. It is reasonable to suppose that the individual presenting some bone anomaly in the lower back is peculiarly weak and susceptible to strains. The pelvic tilt caused by unequal length of legs throws undue strain upon all the ligaments of the lower back. A sacralized fifth lumbar on one side throws undue activity and strain on the ligaments of the other side. That the lumbo-sacral region is morphologically unstable is shown by the frequent occurrence of developmental anomalies. However, it is the degree of physiologic balance between the bones and their musculo-ligamentous supports which determines the development of pathologic manifestations. It is never safe to base judgment on anatomic peculiarities alone, no matter how great they are. A bifid spinous process may indicate a potentially weak point of attachment for interspinous ligaments, but, on the other hand, the ligamentous arrangement may be entirely sufficient to compensate for such potential weakness, and if so, symptoms do not appear. The anatomic anomalies of the lumbo-sacral region are legion. Dwight[12] has pointed out that it is almost exceptional to find the fifth lumbar vertebra normal in shape. George[13] has established a normal fifth lumbar by making a composite of tracings of radiographs. This may prove of some value, but I am reminded of photographs of legs of champion sprinters. Some of them are short and stocky, some are long and thin. Both are normal. A composite of them would make an ordinary strong leg. It is not the shape of the leg which gives the speed, neither is it the shape of the fifth lumbar which makes the back ache.*

In 1921 the writer made a review of radiographs showing the lumbo-sacral region of cases in the Rochester General Hospital and of low back cases in his office. It was found that 4.2% of non-orthopaedic backs showed anomalies; 6.5% of the Hospital low back strains showed anomalies; and 8.1% of the office series of low back strains showed anomalies.

* Rugh reports a radiographic study of 200 cases for other than spinal conditions, in which 42% were found to have some developmental defect in the lumbo-sacral region without symptoms.

In a series of 1000 mixed cases coming for radiographs in which the lumbo-sacral region was shown, Baetjer found non-union of the laminae in 15%.

Baer and Baetjer found anomalies five to seven times oftener in cases of back strain than in other types of cases. They found anomalies in four cases of low back strain, to every one case of genito-urinary disturbance.

The Hospital series of back strains probably represented a more severe type of injury than a series coming to an office. Hence, the anomaly did not participate to quite so large an extent in the disability. The only marked differences between the non-orthopaedic series and the orthopaedic series were in proliferative arthritis, and in the shapes of the transverse processes. There was no case of proliferative arthritis in the non-orthopaedic series, whereas 14% of the orthopaedic series showed it. Eighty-four per cent. of the transverse processes of the fifth lumbar of the non-orthopaedic series were straight and narrow; whereas only 45% of the orthopaedic series were so. Only 16% of the transverse processes in the non-orthopaedic series were bulbous or fish-tailed shape; whereas 60% in the orthopaedic series were so.

Hibbs is so impressed by anatomic variations as the cause of symptoms that he predicts the time of exploratory operations on the lower spine. A failure in development of the pedicles of the fifth lumbar or first sacral, leaving the lamina freely movable and permitting great shearing stress or spondylolisthesis, is obviously an anomaly of serious clinical moment. Cunningham[14] says, "The neural arch of the fifth lumbar vertebra is occasionally developed from two centers on either side, as is demonstrated by the fact that the arch is sometimes divided by a synchondrodial joint, running obliquely across between the superior and inferior articular processes on either side," *i.e.*, just posterior to the pedicle. Hibbs reports that Huntington of Columbia has numerous such specimens. Hibbs reports two such cases coming to operation. Fitch operated upon a spondylolisthesis to produce fusion and found such a condition. A. Whitman[15] reported such a case.

Sacralization. Sacralization is a partial or complete fusion of the fifth lumbar vertebra and the sacrum, or an articulation of the transverse process of the fifth lumbar with the ilium. Normally, the transverse process lies in a plane anterior to the wings of the ilia, and in the presence of a lumbar lordosis or a spondylolisthesis would be placed still further forward, so that the process would have to be large enough to amount to a sacralization before any impingement upon the ilium could occur. There are, however, some instances where the sacrum is set so low between the ilia that a long transverse process may strike. The unilateral impingement of a transverse process upon the base of the sacrum causes a leverage producing strain of the lumbo-sacral ligaments on the other side and limits lateral mobility at this articulation. If the transverse process is still larger, a distinct articulation, named the lumbo-sacral transverse articulation by Dwight, is found at this point. A similar impingement and leverage, tending to

pry apart the articular processes, may be produced when the superior surface of the lateral portion of the sacrum is higher than the spinal articular surface. This condition approaches that of sacralization.

Literature on the subject of sacralization as a cause of pain has practically all appeared in recent years and follows radiographic investigation.* There are several theories of the mechanism by which complete or incomplete sacralization may produce pain:

1. Pressure of muscle or ligament between the transverse process and the ilium.

*In 1910, Z. B. Adams[16] reported relief of a left lumbar scoliosis following removal of a large fifth lumbar transverse process on the right which impinged on the ilium. In 1919, A. J. Richard[17] reported 36 cases of pain in the lumbo-sacral region associated with abnormal fifth lumbar transverse processes. He concludes that complete fusion of the fifth lumbar vertebra with the sacrum is the end of the evolutionary process, because man in the erect position doesn't need as many lumbar joints and has great mechanical disadvantage with the average lumbo-sacral angle, and that the uncompleted evolutionary attempts at this fusion are the cause of much low back pain. Hibbs, his clinical chief, grasps this clue to produce fusion therapeutically.

In 1921, M. R. Hayes[18] reported six cases, stating that up to that time no operative case of complete cure had been reported and that in only two of his cases were the symptoms inexplicable in any other way. In 1922, Holland of Liverpool reported ten cases, but has no convincing evidence that the sacralization was the actual cause of pain and has no convincing operative cure.

In 1922, A. Leri[19] studied 100 radiographic cases and concluded that sacralization is rarely a cause of pain; that the complete or relative failure of the majority of operations of removal of transverse processes does not justify a general adoption of the term "painful sacralization."

J. R. Kuth[20] in a series of 208 cases classified nine as anomaly of the transverse process of the fifth lumbar. By that, he meant clubbing, sacralization, and impingement of the process. In none was the transverse process removed. Kuth felt that in only one could the symptoms be attributed directly to abnormalities of the transverse process with any degree of probability.

Archer O'Reilly[21] believed, from radiographic studies alone, that overlapping transverse processes were common in cases of back pain but admitted that it was impossible to tell whether this was a mere overlapping of shadows or whether there was an actual contact. After he had made dissections of cadavers which had been radiographed, however, he felt that the radiograph was very apt to show merely overlapping of shadows without bone impingement, and that the distance between the tip of the transverse process of the fifth lumbar and the ilium is so great that it would seem almost impossible for them to come in contact. He felt that there is more likelihood of impingement of the inferior border of the transverse process on the base of the sacrum.

Rugh says that before a diagnosis of impingement of transverse process can be made, radiographs must be made in five different directions,—"(1) anterior posterior; (2) oblique from above downward; (3) oblique from below upward; (4) oblique from the right side; (5) oblique from the left side." Evidently he feels that if this standard is maintained enthusiasm for the diagnosis will be minimized.

Galloway[22, 23] reports that in his experience, "some cases of lumbago and sciatica," have been relieved instantly and permanently by removal of transverse processes. He has removed over fifty transverse processes but he does not know, before operation, whether the case will be relieved or not. His belief is, apparently, that the leverage action of an impinging transverse process is responsible for chronic strains.

Bauman[24] reports twenty cases of lesions of the lumbar transverse processes. The injury factor is strong. There are fifteen of sudden injury. usually indirect, with an

2. Irritation or arthritis of abnormal joints or bursae.

3. Strain of the sacro-iliac or lumbo-sacral joints, due to leverage of a transverse process on the ilium or sacrum.

4. Stretching or pressure on the nerves of the lumbo-sacral plexus.

They are all plausible and probably do occasionally exist in fact. There is, however, one common significant fact about pressure. Fractures of transverse processes are of common occurrence. Swelling and pressure upon the closely approximated portions of the lumbo-sacral plexus must follow; yet usually the pain is localized and non-radiating.* Logic and the preponderance of evidence at the present time are against sacralization and large transverse processes being the etiologic factor in back pain, with or without radiating pain, except as unusual leverage action may produce ligamentous strain or nerve injury.

additional two of possible injury. There is a fair amount of evidence of nerve irritation or injury. In nineteen cases the operation was performed with reported good results.

Moore[25] reports nine cases of sciatic irritation associated with a spinal list away from the affected side. They usually have limited lumbo-sacral motion. All have abnormalities of the transverse process of the fifth lumbar. Moore concludes that in five of the seven cases in which transverse processes were removed, relief from sciatic pain was striking, disappearing by the fifth day in three and by the fourteenth day in the other two.

Subjecting all of these cases to a standard analysis and requiring, for a case to be convincing on the necessity or curative value of removal of the transverse processes, one may reasonably demand: 1. A considerable period of pre-operative disability with failure of other forms of treatment; 2. A definite lesion of some kind associated with a transverse process; 3. Relief persisting after a considerable post-operative period. In Bauman's series of nineteen cases operated, there are four convincing cases and fifteen decidedly unconvincing cases. In Moore's series of nine cases, there is one convincing case. The chief fault in the unconvincing cases is the time factor, which is usually not long enough, post-operatively, to show whether cure really has been obtained. Some did not have enough of a pre-operative period to show whether removal was necessary. Some had no real transverse process factor in them, so far as the evidence given shows.

In a later article Bauman[26] says that in recent or mild cases operation is not advised. He reports that fourteen of his nineteen operatives are cured, three improved, and one unimproved.

*H. W. Wright[27] reports some interesting cases in point:

Case 1. The patient fell, striking the lower part of the back, and sustained a fracture of the right transverse process of the fifth lumbar. There was diminished sensibility to light touch in the distribution of the anterior crural on the left (opposite side), with hyperesthesia to painful stimuli, exaggerated patellar reflexes, and absent Achilles reflex on the injured side. A month later pain along the right sciatic began and persisted at least two years. These nerve findings represent a plexus injury, not the pressure of a fractured transverse process.

Case 2. Following a violent body twist, and a crushing by a heavy timber, the patient sustained a fracture of the right transverse process of the fifth lumbar. There was immediate severe pain in the right inferior gluteal nerve; later, in the right sciatic. Two months later there was pain in the right buttock and sacro-iliac region, loss of tone, with some atrophy of the gluteus maximus, and weakness of the tensor fasciae femoris. The transverse process was removed, but two years later there was still considerable disability. This was a severe plexus injury with interruption of fibers going to the inferior gluteal nerve, and an intra- or extra-neural lesion of the sciatic. The lesion of the transverse process was incidental.

Sciatica. Sciatica, a term formerly used much more than now, was generally confused with sciatic pain from irritation or compression of nerve roots and trunks, and consequently fell into disrepute among orthopaedic surgeons.*

The term sciatica should be restricted to cases of pain in the course of

* In 1917, M. H. Rogers[28] reported from the Massachusetts General Hospital fifty cases of sciatic pain, in which forty-nine showed joint lesions of the lower spine and pelvis. The "definite evidence of a joint lesion" which he used was loss of motion in a joint and pain on motion in the joint associated with an increase of sciatic pain when the joint was moved. His article has been severely criticized by neurologists, who maintain that[29] one has not the right to classify a large number of joint cases as sciatica and then argue from his statistics that sciatica does not exist; and that[30] on the whole, orthopaedic surgeons look upon sciatic pain from the circumscribed point of view of their field. In justice to Rogers it should be recorded that he concludes that "it is not the presumption that the only cause of sciatic pain is a joint lesion," but that a joint lesion is often overlooked as a cause. Orthopaedic surgeons have not been overlooking joint lesions as a cause of sciatic pain lately, but they may have failed to show actual relationship between joint lesions and sciatic pain.

J. A. Nutter[31] concludes that 80% to 90% of cases of referred sciatic pain in the Montreal General Hospital are from neighboring joints, principally the lumbo-sacral, next the sacro-iliac, and last the hip. Nutter enumerates other causes of sciatic pain: syphilis, which may be a meningitis; an arthritis of the lower spine; a periostitis; or a true gummatous neuritis; gonorrhea, which may be either arthritis or neuritis; varicose veins in the nerve sheath; any form of pelvic disease which may cause pressure, such as neoplasms, tuberculosis with psoas abscess, spine, sacro-iliac, or hip joint involvement, and variations in the lower spine.

E. W. Fiske[32] reports a series of twenty cases of sciatic pain, 55% of which were secondary to sacro-iliac strain, 25% to lumbo-sacral strain, 15% to muscle strain of the back, 10% to bone infection, and a possible 15% to bone anomaly as revealed in the radiograph. He concludes that direct pressure upon the lumbo-sacral plexus is the usual cause, with reflex pain from affected joints secondary.

John Cowan[33] reviewed forty cases of sciatica, noting the great frequency of sacro-iliac pain associated with sciatica. He said that pressure on the sacro-iliac joint caused acute pain down the sciatic nerve more than pressure over the nerve itself. It does not seem possible that he was dealing with true sciatica.

Ott,[34] of the Mayo Clinic, reported forty-eight cases in which all extraneural causes of sciatic pain were ruled out. Ninety-six per cent. of these had pain over the sacro-iliac region and 77% of them had pain over the lumbar region. Ninety-two per cent. were tender over the sciatic trunk. In 96% Lasègue's sign was positive. Thirty-seven per cent. presented atrophy of some of the muscles of the extremity and in 50% the Achilles reflex was diminished or absent.

The members of the American Orthopaedic Association are familiar with John Ridlon's personal testimony to toxic neuritis of the sciatic relieved by senna tea. Freiberg, however, feels that there must be some localizing factor. W. J. Taylor[35] of Philadelphia has demonstrated beyond question of doubt the existence of sciatic perineuritis by exposing the sciatics in a number of persistently disabled individuals and finding the trunks red and actively inflamed; congestion, swelling, firm adhesions binding the nerves to surrounding tissue and particularly hindering motion at the points where branches join the trunk. This evidence is particularly striking when one considers the relief following neurolysis.

Danforth and Wilson[36] have called attention to the fact that the nerve foramen at the lumbo-sacral articulation is the smallest, whereas the nerve itself is the largest, and the foramen at the fourth-fifth lumbar is the next smallest, and the nerve the next largest; that hyperextension of the spine might produce impingement of the nerve by the lower articular facet. Their clinical and radiographic findings in cases of sciatic pain are largely in the lumbo-sacral region.

the sciatic nerve or its branches, where disease in the pelvic cavity or neighboring joints has been excluded. Sciatica is a perineuritis, radiculitis, neuritis, or neuralgia.

There is reason to suppose, and evidence to bear out the supposition, that in a lesion in the lower back following trauma, the nerves, as well as the bones, muscles, and ligaments are involved. The nerve trunks making up the lumbar and sacral plexus lie in the closest possible relationship to the transverse processes of the lower lumbar vertebrae, to the articular facets, to the sacrum, and to the sacro-iliac joints. This means that excessive motion, lacerations producing hemorrhage, bacterial and toxic irritations of the joints producing swelling or arthritic hyperostoses, may cause nerve pressure. Following hemorrhage, cicatricial contractions may again irritate nerves. The symptoms resulting may be severe or mild, and may be referred anywhere in the course of the sciatic, lesser sciatic, sacral, gluteal, anterior crural, and obturator nerves.

Davis believed that as a result of strains, the nerves are stretched. He considered this a very prolific source of low back pain. The form of lesion may be undemonstrable, but that either intra-neural or extra-neural lesions exist are shown by such signs as persistent pain in spite of immobilization, sensory losses or disturbances, loss of muscle tissue, isolated muscle weakness, altered patellar and Achilles reflexes, trophic changes, and chronicity of symptoms. In chronic relaxations, the mechanical changes may take place so slowly that nerves become adjusted to the changed conditions without irritation.

True sciatica is a neuritis, and is a primary involvement, giving symptoms of organic nerve disease: nerve tenderness, anesthesia, atrophic muscular paresis, and reaction of degeneration. Common causes are infections, toxemias, constitutional diseases such as anemia, diabetes, and alcoholic intoxication. True sciatica must be differentiated from the traumatic etiologies of sciatic nerve pain, such as laceration of, or pressure upon nerve fibers.

Gluteal Myositis. Gluteal myositis is either due to an inflammatory reaction in the muscles supplied by the superior gluteal nerve, or to some inflammatory condition of the nerve itself. To substantiate the former view, one of the cases from which muscle was removed for study at the Hospital for the Ruptured and Crippled showed an acute myositis. In support of the latter view, the clinical experience of relief from pain by shortening the distance between the origin and insertion of the muscle may be due to the release of tension stress upon the nerve. The name signifies that the former is the predominating opinion.

Fibrositis. Galloway explains many of the low back pains as chronic fibrositis. The increase of symptoms during certain weather conditions he explains by the difficulty of circulatory alterations in fibrous tissues to compensate for barometric changes. Chronic fibrositis is probably nothing but nerve irritation by organized blood clot,—minute adhesions.

Gluteal Bursitis. A. J. Gillette,[37] at operation on several cases, found a distended gluteal bursa to be the cause of sciatic pain.

Tuberculosis, syphilis, primary and metastatic neoplasm, focal infections, and toxemias require no special discussion here. Not enough is known concerning the chronic lumbar rachialgia of Forestier,[38] Sicard,[38] and Erben,[39] of arterio-sclerosis of posterior ganglia,[40] spinal meningeal hemorrhage, meningeal varicosities, and calcareous deposits or atheromatous changes in the aorta[41] as causes of low back pain to warrant discussion here.

The information recorded in the third section of this paper was obtained by reviewing seven hundred and fifty low back cases, each studied with as much care as possible under personal observation. It is recorded not to support any theory, but to see if it will show any significant fact or suggest any clarification of the avowedly muddy situation in diagnosis of low back cases. The form on which records are taken is attached.

Information is graphically presented on the charts attached. The size of the blocks represents the relative number of cases under each diagnosis which had that particular finding. In the larger chart the plottings were done to the nearest ten per cent. and no record made when less than five per cent. of the cases had the finding. In the smaller chart the plottings were made to the nearest twenty-five per cent. and no record made when less than twelve per cent. showed the findings.

The cases of low back pain from chronic bone infections and neoplasms, from neuralgia, neuritis, perineuritis, and radiculitis, and from nerve injuries were omitted from the charts because of insufficient number of such cases to make the data valuable. Cases of myositis and muscle injury were omitted because the diagnosis is almost always so obvious.

From the smaller chart have been eliminated all findings which have no differential value in the diagnosis of sacro-iliac strain, sacro-iliac subluxation, lumbo-sacral strain, static strain, fracture and dislocation of the lumbo-sacro-iliac region, and osteoarthritis of the spine and lumbo-sacro-iliac region. Many findings are of value in getting leads, in sizing up a patient to determine whether there is anything at all the matter, or whether the condition comes within the orthopaedic field, but have no value in differentiating among the several specific conditions which interest us at

present,—for example, a history of light trauma. A very large number of patients who have not had severe trauma have been able to trace a low back pain to light trauma. Almost all, except the static back cases, say that the pain is aggravated by spinal motion or stress.

It would seem strange to leave out of a differential diagnostic chart the data on radiating pains. This was done because the only radiation which any considerable number of patients reported was that down the posterior part of the lower extremity, and that radiation was present in all of the diagnoses to approximately the same degree. Furthermore, localization of radiating pain is very inaccurate. Pain shoots very rapidly, and unless the radiation is often repeated, none but a careful observer is apt to have any scientific knowledge of where it does shoot. When a reliable history of radiating pain is present, it is of great value in localizing a lesion, but from the broad statistical point of view, this rarely occurred.

Spinal deviations or lists are present commonly and about equally commonly in each class of case.

Pronation of the feet is decidedly more common in cases of static strain than elsewhere, but no differential diagnosis of low back pain would hinge on the presence or absence of foot pronation alone. It is usually a part of general bad posture.

Of the manipulations and active movements carried out as diagnostic procedure this series showed that where a moderate degree only of limitation of spinal flexion existed, and where the range of spinal flexion was normal there was no marked differentiating value found.

The degree of spinal flexion was determined by marking a spot on the skin over the first lumbar spinous process and another over the first sacral spinous process. The distance between these points was then measured with the patient erect and again in as much spinal flexion as could be obtained. If, for example, these measurements are 16 cm. and 24 cm. the percentage increase is 50%.

It was found that normal backs, cases of static back strain, and cases of sacro-iliac strain give a 40% increase; that cases of lumbo-sacral strain and muscle strain give a 30% increase; and that fractures, osteoarthritis, and acute spinal arthritis give a 25% increase. Of course, many of the acute fracture cases and recently injured osteoarthritic cases show less than 10% increase. The figure of 25% increase is an average including many old fracture cases and remotely injured osteoarthritic cases.

A tabulation of the cases regardless of diagnosis but with respect to age showed that individuals under 30 years of age showed a 37% increase, individuals between 30 years and 50 years showed a 31% increase, and

individuals 50 years and over showed a 28% increase. This indicates the importance of taking into consideration the age of the individual as well as the percentage increase of distance between the spinous process of the first lumbar and the first sacral when utilizing data on spinal flexibility.

Pain on straight leg raising between 140 degrees and 80 degrees, and on thigh hyperextension is present so often that it has no differentiating value.

Audible hollow snapping sounds, apparently originating somewhere about the pelvis, are more frequent in sacro-iliac cases than elsewhere, but do occur in all of the diagnoses. They are also so difficult in localization, sometimes being equally loud, when tested with a stethoscope, over spinous processes as over sacro-iliac joints, and usually unaccompanied by pain, that they are of very little value. Patients usually are not even aware of them, when elicited at examination, until attention is called to them by the examiner.

Pain on punting and hyperextension kicking is of value in determining the presence of some lesion, but is of no particular value in determining what specific lesion, except that it is uncommon in cases of static strain.

Rectal examination was only occasionally made. It gave practically no information of value.

From a statistical standpoint localized tenderness is the only nerve finding of differential value. The altered patellar and Achilles reflexes, muscle atrophies and paralyses, localized clonic contractions, trophic changes, areas of decreased or altered tactile sensibility and hyperalgesias play an important rôle in cases of neuralgia, neuritis, perineuritis, radiculitis, and nerve injury,—not charted; but these findings were so rarely present in the six types charted that their relative value is small.

It will be noted first that of the sixty-four charted findings there are

55 in osteoarthritis.....	*i.e.*, 86% in number of findings
49 in sacro-iliac subluxations ..	76%
46 in lumbo-sacral strains.....	72%
44 in fractures and dislocations	68%
42 in sacro-iliac strains.....	68%
38 in static strains.....	58%

In other words, osteoarthritis presents more different forms of evidence of its presence than any of the others, and static strain presents less different forms of evidence of its presence than any of the others. But of the 55 findings in osteoarthritis and the 44 of fractures and dislocations only one —the radiograph—is necessary to make the diagnosis certain. This is always present. In the fractures and dislocations, furthermore, there is

always a history of severe trauma, of pain aggravated by spinal motion or stress, and of pain immediately following injury.

It will be noted next that the average elevation of the curves is as follows:

Fractures and dislocations	41%
Sacro-iliac subluxations	34%
Osteoarthritis	29%
Lumbo-sacral strains	28%
Sacro-iliac strains	25%
Static strains	20%

It will be noted that there are more high points in the curve of fractures and dislocations than of any other curve, giving a 41% average positivity of findings. There are less high points in the curve of static strain than in the curve of any other diagnosis, giving an average of 20% positivity of findings.

A careful examination, then, should always enable one to make a diagnosis of osteoarthritis or of fracture or dislocation. I think practically no exception will be taken to such a statement.

The diagnosis of static strain is perhaps a weak diagnosis. Except for bad posture, and a history not suggestive of trauma, there is no striking uniformity of findings. Muscular atony, asthenia, tenderness over the lumbo-sacral region and over sacro-iliac joints appear in a half of the cases. Movement is not painful or restricted unless the joint structures have become altered by incorrect statics. The diagnosis is usually a process of elimination of definite lesions in the presence of bad statics.

Let us consider the differentiations between lumbo-sacral and sacro-iliac lesions. A glance at the differential diagnosis chart will show sharp differences in the history, radiographic and local tenderness curves. The sacro-iliac cases show severe trauma. The lumbo-sacral cases do not. The lumbo-sacral cases show an occupational factor and lumbar pain. The sacro-iliac cases do not. The lumbo-sacral cases show lumbo-sacral and lumbo-iliac pain. The sacro-iliac cases show sacro-iliac pain. The lumbo-sacral cases show much more marked radiographic findings than the sacro-iliac cases. In fact, the only radiographic findings in sacro-iliac cases are anomalies suggesting undue leverage upon one of the sacro-iliac joints. The anomalous articular facets of the fifth lumbar and first sacral, the bifid spinous processes, impingement of spinous processes, sharp lumbo-sacral angle, and large transverse processes of the fifth lumbar, make the lumbo-sacral and lumbo-iliac findings high. The lumbo-sacral cases show lumbo-

sacral, spinous process, lumbo-iliac, and sacral tenderness. The sacro-iliac cases show sacro-iliac tenderness.

There is no conclusive differentiating evidence in the field of nerve irritation or referred pain. Occasionally this is of value, but from a broad statistical standpoint the evidence appears too seldom to record differentiating value.

Likewise there is great confusion in the evidence obtained from manipulations and active movements. Straight leg raising between 180 degrees and 140 degrees does not give pain in lumbo-sacral cases. It gives pain in severe sacro-iliac cases but does not in mild ones. Straight leg raising between 140 degrees and 110 degrees gives pain a little more often in sacro-iliac cases than in lumbo-sacral cases, but not strikingly so. Straight leg raising between 110 degrees and 80 degrees gives pain in almost any kind of a low back case. Thigh hyperextension appears to give pain in nearly all low back cases.

Spastic limitation of spinal motion appears in severe or acute cases of either lumbo-sacral or sacro-iliac strain, and is absent in mild or chronic cases of both types. A moderate degree of limitation of spinal flexion, a normal range of spinal flexion, a limitation in range of spinal extension, of lateral bending and of rotation of the spine appear to be about equally prevalent in both types of case.

Pain on crest compression is limited to sacro-iliac cases, but is present in only a small percentage of them. The test is only of value if the patient is horizontal on a hard surface and a great deal of weight is placed upon the upper crest.

The manipulation and motion finding confusions are due to the extreme difficulty of fixing the spine so as to relieve it of stress while placing stress on the sacro-iliac joints, or of fixing the pelvis to relieve the sacro-iliac joints of stress while placing stress on the lumbo-sacral juncture or spine.

From a statistical standpoint, then, a differentiation between lumbo-sacral and sacro-iliac cases rests upon:

Lumbo-Sacral	*Sacro-Iliac*
Occupational lumbo-sacral stress.....	.....
Lumbar pain.....	.....
Lumbo-sacral and lumbo-iliac pain....	Sacro-iliac pain
Radiographic findings.....	.....
Lumbo-sacral, lumbo-iliac, spinous process, sacral tenderness.....	Sacro-iliac tenderness
.....	Pain on straight leg raising between 180° and 140° in acute or severe cases.
.....	Pain on crest compression.

The term subluxation of the sacro-iliac joint was not used in any case except where restoration was obtained by manipulation. From a diagnostic standpoint, however, such a criterion is not a fair one. The surgeon must know when to manipulate with a fair degree of certainty of success.

The subluxation is apt to be a more severe lesion than the strain. It shows 76% in number of findings positive against 68% in number of findings positive in the strain. It shows 34% degree of positivity against a 24% degree of positivity in the strain. It shows a higher degree of pain aggravated by spinal motion. Marked limitation of spinal flexion is far more prevalent. Pain is more apt to immediately follow injury. The spine is more apt to be held in antalgic deviation. Bad posture is nowhere near as apt to be a factor as in the strain. There is much more apt to be a flat lumbar spine or kyphosis. Limitation of all spinal motions is more prevalent. Pain on straight leg raising between 180 degrees and 140 degrees is far more prevalent. The area of tenderness is slightly larger, spreading to muscles, spinous processes, lumbo-sacral, lumbo-iliac, and sacral regions with a 28% positivity as compared with a 24% positivity for the strain and a 37% positivity in lumbo-sacral strain. There are also more apt to be radiating pains, diminished tactile sensations in the extremity and altered Achilles reflex.

A sacro-iliac case with marked pain immediately following injury, a flat lumbar or kyphotic lumbar spine, an antalgic spinal deviation, with marked spastic protection against any spinal motions, pain on straight leg raising between 180 degrees and 140 degrees and peripheral nerve findings in the sacral nerves is the proper one for manipulation for relief of distress, and incidentally to clinch the diagnosis of subluxation.

SUMMARY

"Opinion" must give way to "Systematic Diagnosis."

The many pathologies may give rise to similar complaints of pain, weakness, and limited motion, but systematic search reveals discriminating objective evidence of many distinct lesions.

Only a very few cases leave "injury" out of the history.

As a rule histories of radiating pain are inaccurate and of very little differentiating value as compared with subjective location of constant pain.

Sciatic pain is not necessarily sciatica, but may be.

Exaggeration is as common as malingering is rare.

Spinal deviations are of little or no differentiating value.

Posture, including the feet, is an important element in static backs and static sacro-iliac strains.

The flat lumbar spine is common in sacro-iliac subluxation.

It takes a marked degree of limitation in spinal flexion to be of differentiating value.

The age factor must always be borne in mind when considering range of spinal flexibility.

Pain in the back on straight leg raising must occur before the extremity reaches 135 degrees to be of much differentiating value. Above that almost any low back pain will be aggravated.

Pain on thigh hyperextension has no differentiating value.

Audible clicks are not pathognomic of sacro-iliac relaxation.

Reduction of subluxation is a definite scientific procedure evident to both patient and surgeon when obtained.

The subluxation is a more severe lesion than the strain, has more direct relationship to trauma, and quicker pain reactions to manipulations.

Pain on crest compression is limited to sacro-iliac cases, but is not always present in them.

Radiography is absolutely essential in any complete differential diagnostic procedure.

Altered reflexes, muscle atrophies and paralyses, localized clonic contractions, trophic changes, areas of decreased or altered tactile sensibility and hyperalgesia are important in neuritis, perineuritis, radiculitis, and nerve injury, but not in bone and joint lesions.

Areas of localized tenderness are of great value.

The diagnosis of fractures, dislocations, and osteoarthritis may be clinched by the radiograph.

The diagnosis of sacro-iliac subluxation may be proved by a manipulative reduction.

The differentiation between lumbo-sacral and sacro-iliac strains, after all is said and done, depends upon a very few findings: location of the pain and the tenderness, occupation, pain on straight leg raising between 180 degrees and 140 degrees, and on crest compression. Radiography may be of value, but is not essential.

Cases of traumatic strain limited to lumbo-sacral or to sacro-iliac ligaments are rare. In most cases of traumatic strain both sets of ligaments are involved.

The diagnosis of static strain depends upon absence of definite lesions in the presence of poor physical condition or bad body mechanics. Congenital bone anomalies of the lumbo-sacro-iliac region may be contributory factors in many lesions, but the physiologic balance maintained by muscles and ligaments is of more importance than the anatomic bone structure.

Chart I

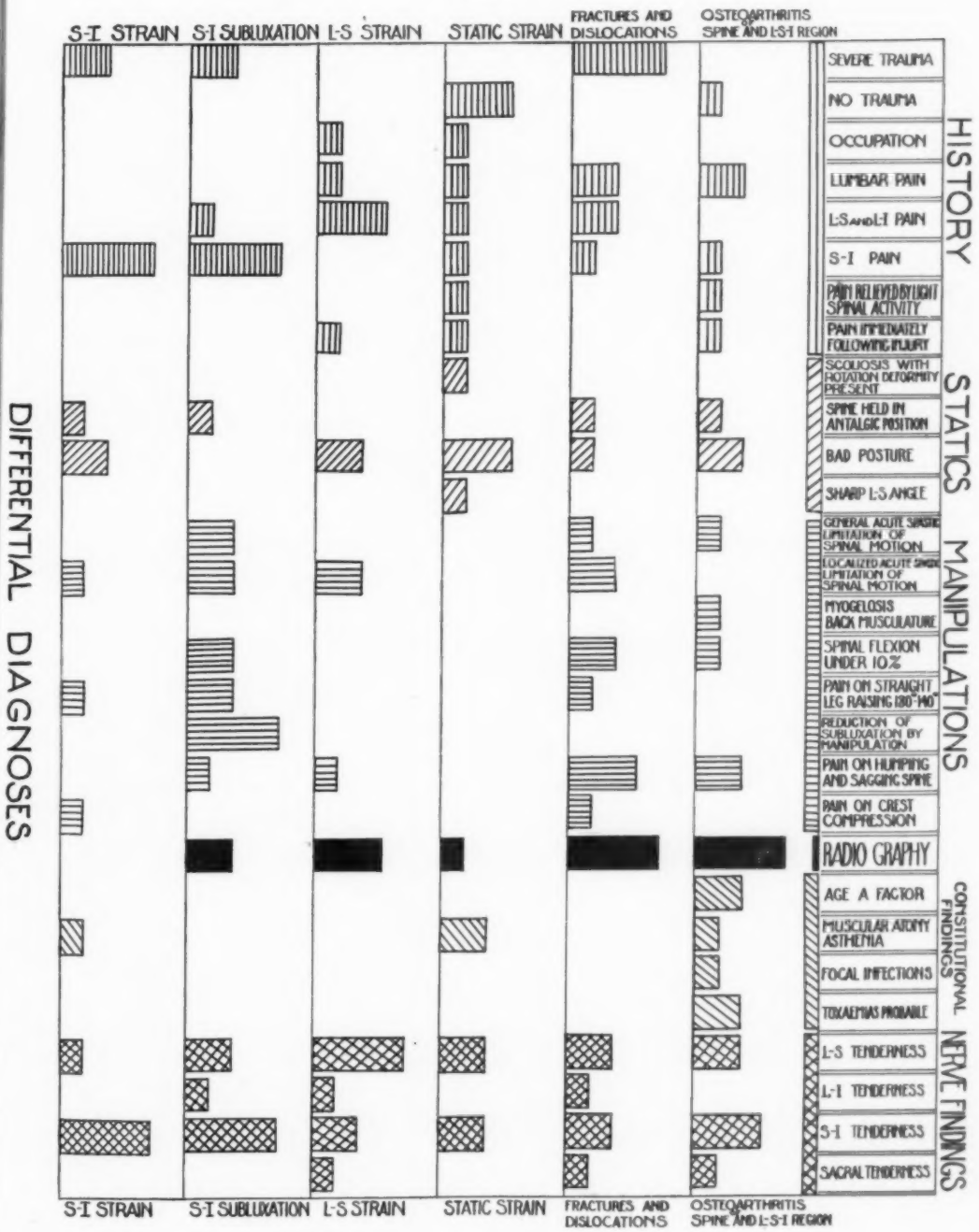
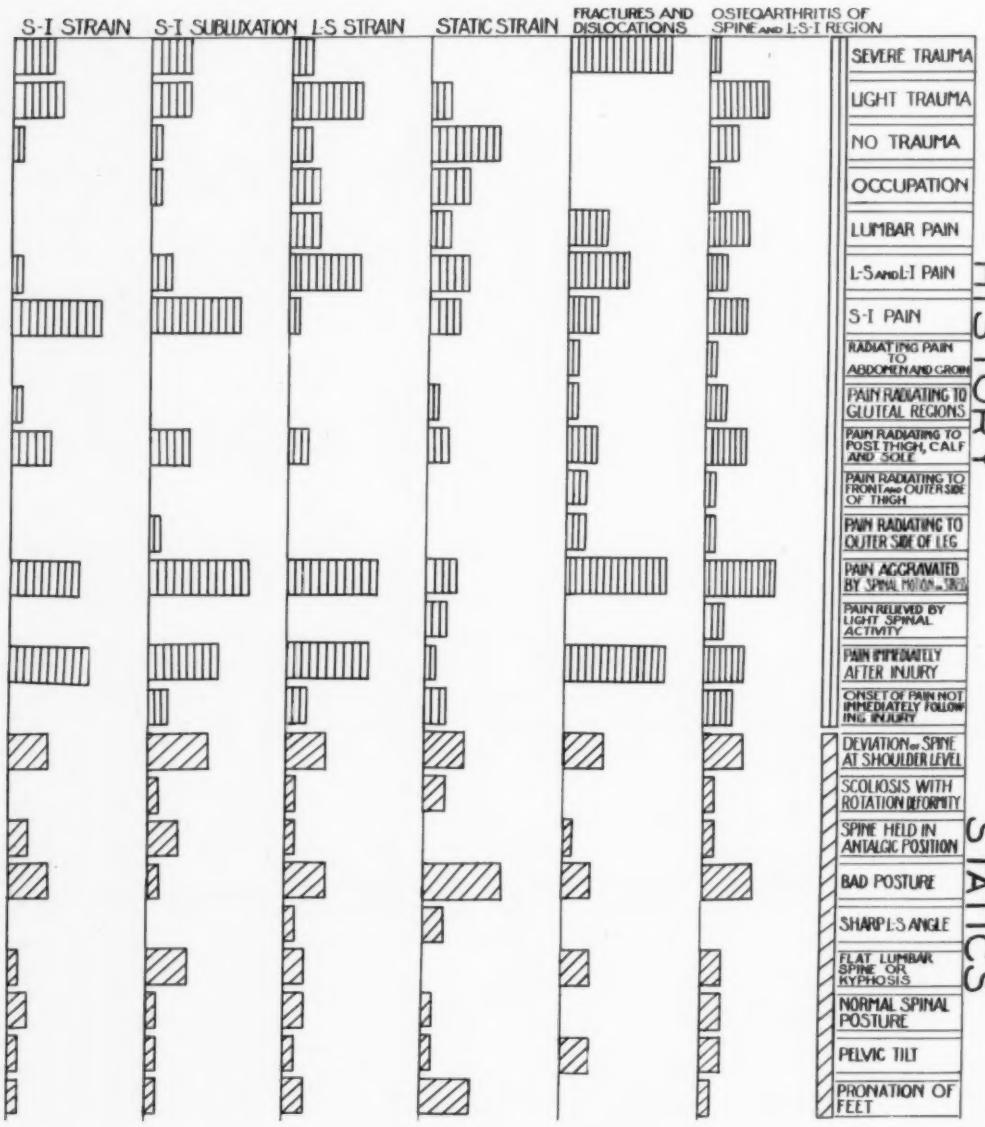
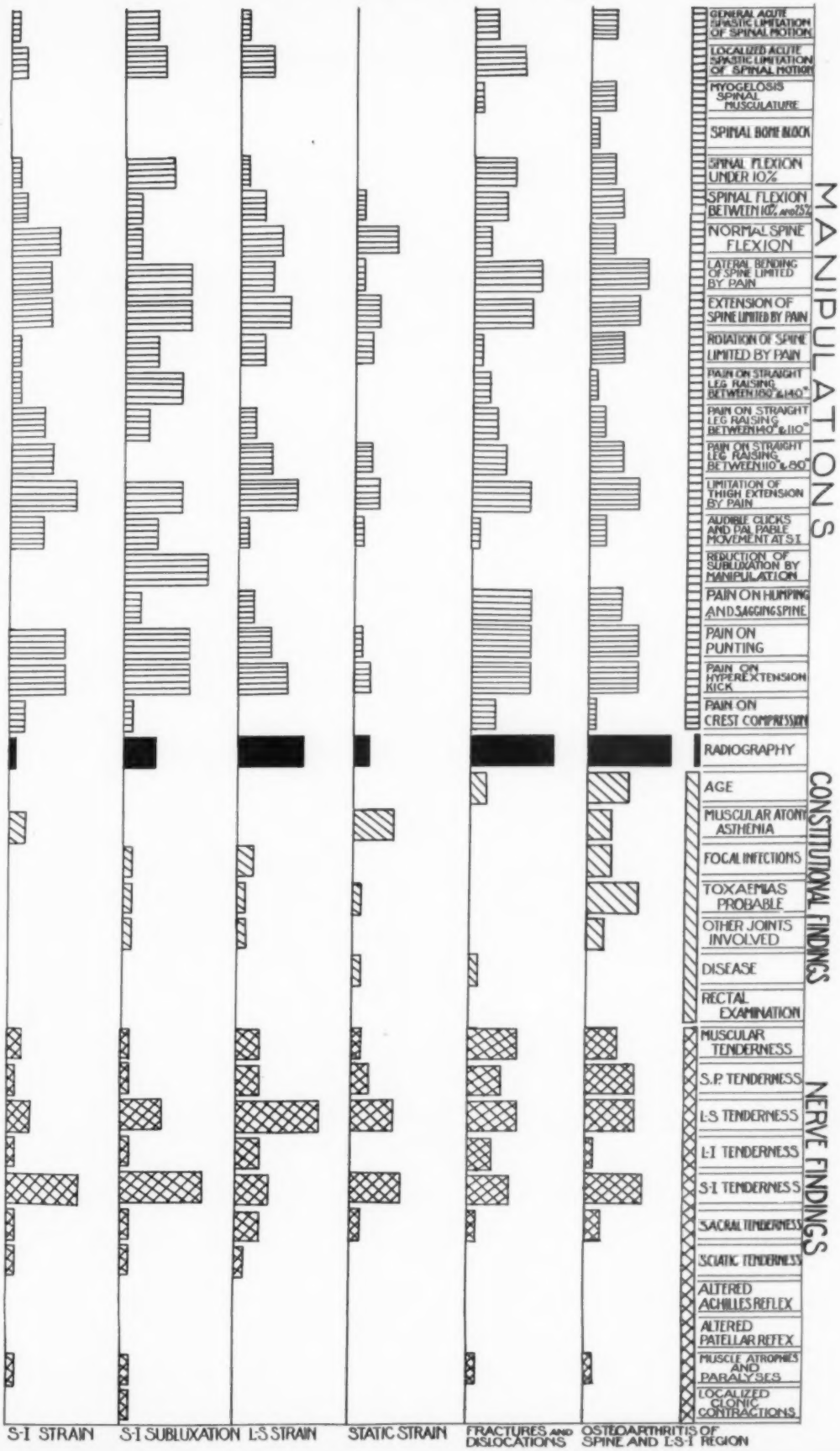

S-I STRAIN
S-I SUBLUXATION
L-S STRAIN
STATIC STRAIN
FRACTURES AND DISLOCATIONS
OSTEOARTHRITIS OF SPINE AND L-S-I REGION
SEVERE TRAUMA
NO TRAUMA
OCCUPATION
LUMBAR PAIN
L-S and L-I PAIN
S-I PAIN
PAIN RELIEVED BY LIGHT SPINAL ACTIVITY
PAIN IMMEDIATELY FOLLOWING INJURY
HISTORY
SCOLIOSIS WITH ROTATION DEFORMITY PRESENT
SPINE HELD IN ANTALGIC POSITION
BAD POSTURE
SHARP L-S ANGLE
STATICS
GENERAL ACUTE SPASTIC LIMITATION OF SPINAL MOTION
LOCALIZED ACUTE SPASTIC LIMITATION OF SPINAL MOTION
MYOGELOSIS BACK MUSCULATURE
SPINAL FLEXION UNDER 10%
PAIN ON STRAIGHT LEG RAISING (80°-140°)
REDUCTION OF SUBLUXATION BY MANIPULATION
MANIPULATIONS
PAIN ON HUMPING AND SAGGING SPINE
PAIN ON CREST COMPRESSION
RADIO GRAPHY
AGE A FACTOR
MUSCULAR ATONY ASTHENIA
FOCAL INFECTIONS
TOXAEMIAS PROBABLE
CONSTITUTIONAL FINDINGS
L-S TENDERNESS
L-I TENDERNESS
S-I TENDERNESS
SACRAL TENDERNESS
NERVE FINDINGS
DIFFERENTIAL DIAGNOSES
S-I STRAIN
S-I SUBLUXATION
L-S STRAIN
STATIC STRAIN
FRACTURES AND DISLOCATIONS
OSTEOARTHRITIS OF SPINE AND L-S-I REGION

Chart II



(Continued on following page)

Chart II—(Continued from preceding page)



Logic and the preponderance of evidence at the present time are against sacralization and large transverse processes being the etiologic factor in back pain, except through unusual leverage action and consequent ligamentous strain.

The diagnosis of nerve injuries, muscle injuries, bursitis, tuberculosis, and neoplasms requires no special comment.

The field of neuritis and perineuritis is covered by the nerve findings.

Syphilis, the personality of the individual, the economic and social backgrounds must never be forgotten.

Case Number Date

History suggestive of severe trauma.
History suggestive of light trauma.
History not suggestive of trauma.
Occupation.
Pain sharply localized—Lumbar.
L—S and L—I.
S—I.
Lower extremity.
Pain radiating—D. L. Abdomen or groin.
S. III, IV, V. Gluteal regions.
S. I, II. Posterior thigh, calf and sole.
L. II, III, IV. Front and outer side of thigh.
L. V. Outer side of leg.
Pain aggravated by spinal motion or stress.
Pain relieved by light spinal activity.
Pain, onset immediately following injury.
Pain, onset not immediately following injury.
Deviation of spine at shoulder level R. L.
Scoliosis present—true with rotation deformity.
antalgic position.
Dorsal round back, lumbar lordosis or enteroptosis.
Sharp L—S. angle.
Flat lumbar spine or lumbar kyphos.
Normal spinal posture.
Pelvic tilt. RA LA RU LU
Pronation of feet.
Limitations of spinal motion—general acute spastic.
localized acute spastic.
myogelosis.
bone block.
Degree of limitation of spinal motion. Flexion marked—under 10%.
Flexion moderate 10%—25%.
Flexion normal 25%—50%.
Lateral R. L.
Extension.
Rotation. R. L.

Limitation of thigh flexion. Pain 180°—140° R. L.
(straight leg raising) Pain 140°—110° R. L.
Pain 110°— 80° R. L.
Limitation of thigh extension R. L.
Audible clicks R. L. Palpable movements R. L.
Reduction of subluxation by manipulation R. L.
Pain on humping and sagging spine.
Pain on punting. R. L.
Pain on hyperextension kick. R. L.
Pain on crest compression. R. L.
Radiography.
Local swelling and location.
Other constitutional findings—Age.
Muscular atony, asthenia.
Focal infections.
Toxaemias probable.
Other joints involved.
Constitutional diseases.
Rectal findings.
Peripheral Nerve Findings. L. I, II.
Decreased or absent sensibility L. III, IV, V.
S. V, IV, III.
S. II.
S. I.
Increased sensibility—gluteals erector spinae.
(tenderness) S. Ps.
L—S.
L—I. R. L.
S—I. R. L.
Sac.
Sciatic. R. L.
Super. Glut. at sacro-sciatic notch.
Altered Reflexes—Achilles (S. I, II.) R. L.
Patellar (L. III, IV.) R. L.
Muscle atrophies and paralyses.
Tropic changes.
Localized clonic contractions.
Exaggeration or dissimulation apparent. Inconsistent picture of objective findings. Compensation and public liability laws involved. Grievances.

Sacro-Iliac Strains

Percentage of cases presenting:

Pain aggravated by S-I stress	94
Pain sharply localized in S-I region	93
Tenderness over S-I joint	89
Limitation of thigh extension by pain at S-I joint	81

Onset of pain immediately after injury	80
Pain aggravated by spinal motion or stress	70
Pain on punting	69
Pain on hyperextension kicking	69
Normal range of spinal flexion	62
History suggestive of light trauma	49
Pain on straight leg raising between 110 and 80	48
Pain on lateral bending of the spine	48
Pain on extension of the spine	47
History suggestive of severe trauma	39
Abnormal mobility in S-I shown by click and palpable motion	39
Poor spinal posture	39
Deviation of spine from vertical at shoulder level	38
Pain radiating down posterior thigh, calf, or in sole	36
Pain on straight leg raising between 140 and 110	35
Lumbo-sacral tenderness	33
Localized acute protective spasm	24
Spinal flexion markedly limited	21
Normal spinal posture	20
Pain on crest compression	18
Muscular atony, asthenia	16
Muscular tenderness, gluteals largely	16
Antalgic position of spine	16
Pronation of feet	14
Pain on straight leg raising between 180 and 140	12
History not suggestive of trauma	12
Flat lumbar spine	12
Radiography shows contributory anatomy	12
Sciatic nerve tenderness	10
Pain localized L-S and L-I regions	10
Pain on rotation of spine	10
Pelvic tilt present	9
Pain radiating into gluteal regions	7
Marked limitation of spinal motion	7
Tenderness over sacrum	7
Tenderness over L-I region	7
General acute protective spasm	6
Muscle atrophies and paralyses	6
Tenderness over spinous processes	6
Occupation	4
Onset of pain not immediately following injury	4
Scoliosis with rotation deformity	4
Constitutional diseases present	4
Localized clonic spasm in extremity	4
Age	4
Pain radiating to outer side of leg	3
Rectal findings	3
Decreased or absent tactile sensibility in distribution of S. I	3

Pain on humping and sagging spine	3
Exaggeration or dissimulation apparent	3
Pain radiating into abdomen or groin	3
Pain radiating to front and outer side of thigh	1
Sharp L-S angle	1
Bone block against spinal motion	1
Focal infections	1
Toxaemias probable	1
Decreased or absent sensibility in S. I	1
Hyperalgesias distribution of S. I	1
Altered patellar reflex	1
Local swelling	1

Sacro-Iliac Subluxations

Percentage of cases presenting:

Subluxation reduced by manipulation	100
Pain aggravated by S-I stress	100
Pain aggravated by spinal motion or stress	100
Tenderness over S-I joint	95
Pain sharply localized in S-I region	85
Extension of spine limited by pain	79
Lateral flexion of spine limited by pain	79
Pain on punting	79
Pain on hyperextension kicking	79
Pain on straight leg raising between 180 and 140	72
Limitation of thigh extension	71
Onset of pain immediately following injury	65
Flexion of spine markedly limited by pain	57
Deviation of spine from vertical at shoulder level	57
Localized acute protective spasm	50
Tenderness L-S region	50
History of severe trauma	43
History of light trauma	43
Pain radiating down posterior thigh or calf or into sole	43
Pain lumbar spine	43
General acute protective spasm	43
Pain on spinal rotation	43
Radiography shows contributory anatomy	43
Abnormal mobility in S-I joint	42
Antalgic position of spine	28
Pain on straight leg raising between 140 and 110	28
Pain localized L-S or L-I region	21
Onset of pain not immediately following injury	21
Moderate limitation of spinal flexion	21
Normal range of spinal motion	21
Pain on humping and sagging spine	21

History not suggestive of trauma	14
True scoliosis present	14
Focal infection	14
Tenderness in L-I region	14
Tenderness over sciatic nerve	14
Occupation	7
Pain radiating down outer side of leg	7
Bad posture	7
Normal spinal posture	7
Pelvic tilt	7
Pronation of feet	7
Pain on crest compression	7
Toxaemias probable	7
Other joint involvements	7
Decreased or absent sensibility distribution of S. I	7
Muscular tenderness particularly gluteals	7
Tenderness over sacrum	7
Muscular atrophies and paralyses	7
Localized clonic spasm in extremity	7
Tenderness over spinous processes	7

Lumbo-Sacral Strains

Percentage of cases presenting:

Tenderness in L-S region	95
Pain aggravated by spinal motion or stress	92
Onset of pain immediately following injury	75
Radiographs show contributory factors	75
History suggestive of light trauma	68
Thigh extension limited by pain in L-S region	68
Pain sharply localized in L-S or L-I region	66
Pain on spinal extension	56
Pain on hyperextension kicking	55
Pain aggravated by S-I stress	46
Normal range of spinal flexion	46
Tenderness over S-I joints	43
Pain on straight leg raising between 180 and 140	43
Deviation of spine from vertical shoulder level	41
Bad spinal posture	41
Pain on lateral flexion of spine	41
Localized acute protective spasm	41
Pain on punting	39
Moderate limitation of spinal flexion	34
Tenderness over spinous processes of fourth and fifth lumbar	32
Tenderness over sacrum	29
Tenderness in L-I region	29
Pain in lumbar region	29

Muscular tenderness	27
Occupations	25
Pain on spinal rotation	25
Normal spinal posture	21
Pronation of feet	21
Pain on straight leg raising between 140 and 110	21
Onset of pain not immediately following injury	19
History suggestive of severe trauma	17
History not suggestive of trauma	15
Flat lumbar spine	15
Pain radiating down posterior thigh or calf or sole	15
Pain on humping and sagging of spine	15
Focal infections present	15
Toxaemias probable	12
Limitation of spinal flexion marked	12
True scoliosis present	12
Pain localized in S-I region	12
Sharp L-S angle	9
Muscular atony, asthenia	9
Spine in antalgic position	7
Pelvic tilt	7
General acute protective spasm	7
Clicks	7
Other joints involved	7
Pain radiating to front and outer side of thigh	5
Sciatic nerve tenderness	5
Age	5
Exaggeration and dissimulation apparent	5
Pain radiating to abdomen or groin	2
Pain radiating to gluteal regions	2
Pain relieved by light spinal activity	2
Constitutional diseases	2
Decreased or absent sensibility distribution of L. I, II	2
Decreased or absent sensibility distribution of S. II	2
Muscle atrophies and paralyses	2

Static Strain and Physical Unfitness

Percentage of cases presenting:

Poor spinal posture	78
History not suggestive of trauma	73
Tenderness in S-I region	59
Tenderness in L-S region	54
Normal range of spinal flexion	54
Muscular atony and asthenia	52
Pronation of feet	52
Deviation of spine from vertical at shoulder level	40

Occupation	35
Pain localized L-S and L-I region	35
Pain localized S-I region	33
Limitation of thigh extension by pain	33
Pain aggravated by spinal motion or stress	30
Pain on spinal extension	27
History suggestive of light trauma	23
Onset of pain not immediately following injury	23
Pain localized in lumbar region	21
Pain radiating to posterior thigh, calf or sole	21
Pain relieved by slight spinal activity	21
Sharp L-S angle	21
Tenderness over spinous processes	21
Pain aggravated by S-I stress	19
Pain on straight leg raising between 140 and 110	17
True scoliosis present	15
Pain on hyperextension kicking	15
Radiography shows contributory factor	15
Pain on punting	13
Moderate limitation of spinal flexion	13
Pain on lateral motion of the spine	13
Pelvic tilt	12
Clicks in S-I region	12
Toxaemias probable	10
Constitutional diseases	10
Muscular tenderness	10
Age	10
Dissimulation and exaggeration apparent	10
Pain radiating into gluteal regions	8
Onset of pain immediately following injury	8
Tenderness over sacrum	8
Normal spinal posture	6
Pain on spinal rotation	6
History suggestive of severe trauma	4
Pain radiating to abdomen or groin	4
Flat lumbar spine	4
Myogelosis of back	4
Pain on crest compression	4
Other joints involved	4
Rectal findings	4
Tenderness L-I region	4
Sciatic tenderness	4
Muscle atrophies	2
Local swelling	2
Pain on humping and sagging spine	2
Bone block, spinal	2
Pain radiating to front and outer side of thigh	2
Pain radiating to outer side of leg	2

FRACTURES AND DISLOCATIONS IN THE LUMBO-SACRO-ILIAC REGION

Percentage of cases presenting:

History suggestive of severe trauma	100
Radiographic findings	100
Pain aggravated by spinal motion or stress	100
Onset of pain immediately following injury	100
Pain on lateral motion of spine	80
Pain aggravated by S-I stress	73
Pain on extension of spine	73
Pain on humping and sagging spine	73
Pain on punting	73
Pain on hyperextension kicking	73
Limitation of thigh extension	67
Pain sharply localized in L-S or L-I region	60
Localized acute protective spasm	60
Muscle tenderness	60
L-S tenderness	60
Marked limitation of spinal flexion	47
S-I tenderness	47
Pain sharply localized in lumbar region	40
Pain radiating into extremity	40
Deviation of spine from vertical, at shoulder level	40
Moderate limitation of spinal flexion	40
Pain on straight leg raising between 110 and 80	40
Tenderness over spinous processes	40
Pain sharply localized over S-I region	33
Bad spinal posture	33
Flat lumbar spine	33
Pain on straight leg raising between 140 and 110	33
Pain on crest compression	33
Pelvic tilt	27
General acute protective spasm	27
L-I tenderness	27
Normal range of spinal flexion	20
Pain on straight leg raising between 180 and 140	20
Muscular atony, asthenia	20
Spine held in antalgic position	13
Constitutional diseases	13
Tenderness over sacrum	13
Myogelosis	7
Pain on rotation of spine	7
Clicks in L-S-I region	7
Local swelling	7
Sciatic tenderness	7
Muscle atrophies and paralyses	7

OSTEOARTHRITIS OF SPINAL AND PELVIC JOINTS

Percentage of cases presenting:

Radiographic evidence of bone changes	100
Pain aggravated by spinal motion or stress	68
Pain on lateral motion of the spine	68
Tenderness in S-I region	68
Toxaemias probable	64
Limitation of thigh extension by back pain	64
Pain on hyperextension kicking	60
Tenderness in L-S region	60
Tenderness over spinous processes	56
Pain on punting	56
Pain on spinal extension	56
History suggestive of light trauma	56
Age over 50 years	52
Poor spinal posture	48
Pain localized in lumbar region	44
Pain aggravated by S-I stress	44
Moderate limitation of spinal flexion	44
Muscular tenderness	40
Pain on humping and sagging spine	40
Pain on spinal rotation	40
Onset of pain immediately following injury	40
Pain localized in S-I region	36
Pain radiating to posterior thigh, or calf, or sole	36
Deviation of spine from vertical at shoulder level	36
Pain on straight leg raising between 110 and 80	36
Myogelosis back	32
General acute spastic limitation of spinal motion	32
History not suggestive of trauma	32
Onset of pain not immediately following injury	28
Spinal flexion markedly limited	28
Normal range of spinal flexion	28
Muscular atony, asthenia	28
Focal infections evident	28
Pain radiating to gluteal regions	24
Tenderness over sacrum	24
Other joints involved	20
Pain on straight leg raising between 140 and 110	20
Pain localized at L-S or L-I region	16
Normal spinal posture	16
Pelvic tilt	16
Pain relieved by light spinal activity	16
Clicks	16
Exaggeration or dissimulation apparent (Under Comp. Laws)	16
History of severe trauma	12
Occupation	12

Spine in antalgic position	12
Pronation of feet	12
Tenderness in L-I region	12
Pain radiating to abdomen or groin	8
Pain radiating to front and outer side of thigh	8
Pain radiating to outer side of leg	8
True scoliosis present	8
Bone block	8
Pain on straight leg raising between 180 and 140	8
Pain on crest compression	8
Hyperalgesia distribution of S. III	8
Muscle atrophies and paralyses	8
Paralytic scoliosis	4
Sharp L-S angle	4
Localized acute protective spasm	4
Constitutional diseases	4
Decreased or absent sensibility area of S. I	4
Sciatic tenderness	4
Hyperalgesia region of L. I	4
Hyperalgesia region of S. II	4
Altered Achilles reflex	4
Altered patellar reflex	4
Localized clonic spasm	4

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THE RÔLE OF THE TENSOR FASCIAE FEMORIS IN CERTAIN DEFORMITIES OF THE LOWER EXTREMITIES

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The object of this study is to attempt a more careful analysis of the deformity of hip flexion contracture and the frequently associated deformity of knock-knee and to determine the relative importance of the various anatomic structures involved, and to analyze more particularly the rôle of the tensor fasciae femoris, inasmuch as this structure seems to be one of the chief factors in these deformities.

Although the tensor fasciae femoris is usually mentioned as a factor in the so-called hip flexion contracture of anterior poliomyelitis, its true importance in this and associated deformities has not been clearly defined. The almost invariable coincidence of abduction of the hip with flexion in this deformity is generally accepted, and the operative measures described and generally used for the correction of the deformity attack chiefly the tensor fasciae femoris, the gluteus medius, and the sartorius, and not the hip flexors (ilio-psoas). Moreover, in standard text-books the point is stressed that in testing for the degree of flexion it is essential that the hip be prevented from abducting. Likewise in the treatment of the condition by gradual stretching, this point is especially emphasized. These points tend to call one's attention strikingly to the importance of the hip abductors in a deformity which is called "hip flexion contracture."

For many years it has been the practice of Dr. David Silver and his associates to do simple fasciotomy of the ilio-tibial band above the knee-joint for the relief of hip flexion contracture. At the suggestion of Dr. Silver this study was undertaken to attempt to explain the effectiveness of this simple procedure in this deformity.

ANALYSIS OF THE DEFORMITY OF HIP FLEXION CONTRACTURE

Hip flexion contracture in anterior poliomyelitis is very frequently seen in untreated or improperly treated cases in which the extent of paralysis of the lower extremity is such that walking with or without crutches is impossible or very difficult, but in which the sitting position is possible. As a consequence of this condition the patient sits or is recumbent most of

the time and walks very little or not at all. The position commonly, though not invariably, assumed by these patients in sitting is similar to that of certain Oriental nations where chairs are never used. The thighs are abducted and flexed and externally rotated. The knees are flexed acutely. The legs are crossed at about the lower third and the buttock rests on the inner surface of the feet. Another sitting position occasionally seen, which has been called attention to by Lowman,[14] differs from this in that the legs and feet are placed outside the thighs instead of under them. This deformity is also frequently seen when paralysis is so extensive that the sitting position is not possible. It is probable in these cases

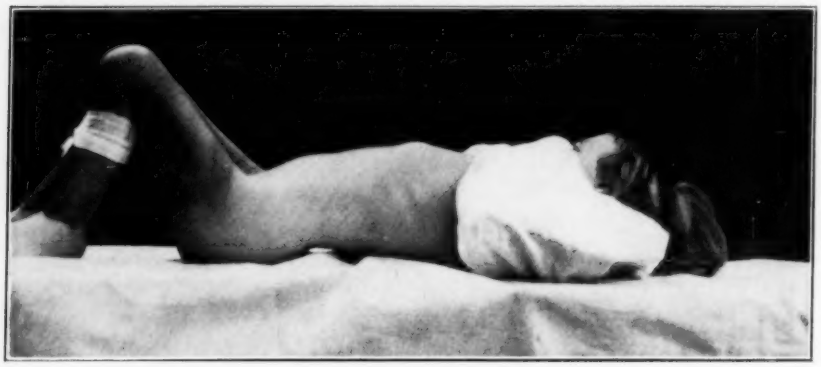

FIG. 1

Bilateral hip flexion contracture, showing the amount of flexion with the limbs in the sagittal plane.

that an habitual position of abduction and external rotation of the hips in recumbency is largely responsible, but paralysis of the adductors is frequently the determining factor. It is believed that these various positions assumed are largely responsible for the development of this typical deformity. It is found that, regardless of the individual muscles or groups of muscles involved, this deformity is frequently seen if there is sufficient paralysis to induce sitting or recumbency. It is also significant that the majority of cases showing this deformity are those in which there is paralysis of varying degree of both lower extremities. Even though it is unusual to find the same group of muscles paralyzed in each limb, the type of deformity is similar in each, provided the total paralysis is sufficient to prohibit ambulation. Even in severe paralysis, if it be largely confined to one lower extremity, and has not interfered with walking with or without

crutches for a prolonged period, this contracture does not usually persist, even though it may have been present in mild degree during the acute and subacute stage of the disease. From the foregoing it is concluded that this deformity may be induced by sitting and recumbency regardless of the particular groups of muscles paralyzed and that the comparatively early resumption of the erect posture in cases of unilateral involvement will prevent it or automatically tend to correct it. In those cases in which a unilateral contracture has persisted after ambulation, recumbency has been enforced long enough to develop a very resistant contracture or the

FIG. 2

Showing that complete extension is possible when the hips are abducted about 50 degrees.

deformity is one resulting more from muscular imbalance than from the effects of posture.

Theoretically, certain combinations of paralysis would tend to favor the development of the deformity on the basis of muscular imbalance; for example, paralysis of the adductors and extensors with active flexors and abductors. However, cases have been observed in which the deformity was well marked and yet the type of paralysis was such that the development of the deformity would seemingly be combated; for example, paralysis of the ilio-psoas, and gluteus medius with active adductors and extensors. Whitman[2] has pointed out the very marked infrequency of paralysis of the tensor fasciae femoris muscle. The relative infrequency of paralysis of this muscle may be a factor in accentuating the deformity or of actually inducing it in cases which are ambulatory and where the sit-

ting position cannot be considered a factor, as such cases, though rare, doubtless exist.

If this deformity were one of true hip flexion, i.e., due to a contracture of the ilio-psoas which is the sole flexor of the hip (McKenzie[12]), then moving the thigh into adduction or abduction would not materially influence the amount of flexion. It is found actually in the majority of these cases that the flexion element of the deformity will completely disappear upon abducting to a variable degree. Then upon attempting to adduct, it is seen that the hip is pulled into flexion and that coincident with this the structures on the outer side of the leg become tense. This tenseness is

FIG. 3

With the left lower limb in the sagittal plane the hip cannot be extended more than is shown.

evident beginning at the anterior superior spine and from the lower third of the crest of the ilium, and involves the entire outer surface of the thigh, but is more particularly evident in the ilio-tibial band, which can usually be seen standing out prominently. This structure is always easily palpable even in obese patients.

The comparative unimportance of the ilio-psoas as a factor in this deformity is indeed surprising. Whitman[2] calls attention to the fact that surgical treatment of the ilio-psoas is practically never necessary even in extreme degrees of the deformity. True flexion contracture of the ilio-psoas uninfluenced by the abductors undoubtedly is occasionally seen, but is probably quite rare.

The sartorius is rarely important in this deformity for the reason that it is a flexor of the knee and not of the hip, so that in the event of contrac-

ture of this muscle, its first deforming action will be flexion of the knee. However, in cases in which there is an associated flexion deformity of the knee of extreme degree, the sartorius might then be contracted to such an extent that it would act to resist extension of the hip. If gradual correction of hip flexion and knee flexion at the same time were attempted by stretching, the sartorius would then be a factor in resisting hip extension.

The rotators of the hip do not seem to materially influence the deformity.

FIG. 4

If the hip is allowed to abduct 45 degrees full extension is possible as shown.

ANATOMIC CONSIDERATION

It is believed that the tensors of the fascia lata play a very important rôle in hip flexion contracture and other frequently associated deformities of the lower extremity, and that there are certain definite anatomic reasons for this which warrant special consideration.

The tensor fasciae femoris muscle performs an additional function to that of abduction of the hip, namely that of rendering the fascia lata tense. In this latter action it functions always in conjunction with the other tensor of the fascia lata, i.e., the gluteus maximus. The anatomic inter-relation of these structures is so close that it is reasonable to assume a commensurate functional inter-relationship.

The tensor fasciae femoris arises from the anterior part of the outer lip of the crest of the ilium and from the outer surface of the anterior

superior spinous process and part of the outer border of the notch below it. Its origin lies between that of the gluteus medius externally and the sartorius mesially. It becomes tendinous about five inches from its origin and there blends with the superficial and deep layers of the fascia lata. Gray describes the fusion of the structures of the outer surface of the thigh as follows: "The fascia lata forms a uniform investment for the whole of this region of the limb, but varies in thickness in different parts; thus it is

FIG. 5

Case showing very marked rotation at the knee-joint (left). The upper line indicates the long axis of the femur. The circle is on the tubercle of the tibia and the lower line follows the crest of the tibia.

thicker in the upper and outer part of the thigh, where it receives a fibrous expansion from the gluteus maximus muscle, and the tensor fasciae femoris is inserted between its layers . . . and again becomes stronger around the knee, receiving fibrous expansions from the tendon of the biceps externally, from the sartorius internally, and from the quadriceps in front." Externally the fascia lata receives the greater part of the tendon of insertion of the gluteus maximus and becomes proportionately thickened. The portion of the fascia lata arising from the front part of the crest of the

ilium, corresponding to the origin of the tensor fasciae femoris, passes down the outer side of the thigh as two layers, one superficial to and the other beneath this muscle. The deep layer is a continuation of the tendinous fibers of the gluteus maximus muscle and the superficial layer is a continuation of the tendinous fibers of the tensor fasciae femoris, but receives some fibers from the fascia covering the gluteus medius. These layers at the lower end of the muscle become blended into a thick and strong band. This band is continued downward under the name of the ilio-tibial band,

FIG. 6

Case showing moderate rotation at the knee-joint (left). The upper line indicates the long axis of the femur. The circle is on the tubercle of the tibia and the lower line follows the crest of the tibia.

to be inserted into the external tuberosity of the tibia. Attention should be called to the fact that the fascia lata is attached to the femur throughout its length by means of intermuscular septa which arise from it, the outer one being the stronger.

The points of practical importance in this descriptive anatomy from the viewpoint of the deformities being considered are: First, that a large part of the insertion of the gluteus maximus is into the fascia lata and not into the femur. From this it must follow that it is in part a tensor of the fascia lata as well as an extensor of the thigh. Second, that that portion of the gluteus maximus which is a tensor of the fascia is in close association

with the true tensor fasciae muscle and that they are continued jointly down the thigh in a distinct thick band (ilio-tibial band), which has its main insertion into the tuberosity of the tibia. Gray,[5] in speaking of the inter-related function of these structures, says: "The tensor fasciae femoris is a tensor of the fascia lata. In the erect posture, acting from below, it will serve to steady the pelvis upon the head of the femur, and by means of the ilio-tibial band it steadies the condyles of the femur on the articular surface of the tibia, and assists the gluteus maximus in supporting the knee in the extended position. The gluteus maximus is a tensor of the fascia lata and by its connection with the ilio-tibial band it steadies the femur on the articular surface of the tibia during standing, when the extensor muscles of the knee are relaxed."

ASSOCIATED DEFORMITIES

There are certain deformities which are very frequently seen in conjunction with hip flexion contracture. The one occurring most frequently is undoubtedly knee flexion contracture. The most important etiologic factor in the development of this deformity is, of course, paralysis of the quadriceps extensor. Paralysis of this muscle, if bilateral, practically prohibits walking in untreated cases, thus, of course, inducing the sitting or lying positions which add an additional factor in the development and perpetuation of this and associated deformities. If, however, there is sufficient paralysis of other muscles to induce these positions, even though the quadriceps may be active, this deformity may develop. The same is true regarding the presence or absence of acting hamstrings, but, of course, normal hamstrings in the presence of a paralyzed quadriceps will surely result in this deformity unless measures are taken to prevent its development, regardless of any postural influence. A deformity frequently seen associated with hip flexion and knee flexion is that generally described as knock-knee. "Children with extensive infantile paralysis of the legs, especially if associated with flexion deformity, are likely to acquire a knock-knee (the mechanism of which has never been quite clear). . . . This knock-knee in its end-result does not differ essentially from the knock-knee of rickets, except in its etiology." (Jones and Lovett.[4]) This deformity is almost invariably present in cases in which the former two deformities are well marked. It is often seen in patients who have not borne weight on the feet since the onset of paralysis, so that from this fact it might reasonably be assumed that in a certain number of cases it is not a true knock-knee, with the changes in the bony structure of the joint

generally accepted as part of the pathology in that deformity, but that it is a deformity due largely to displacement of the tibia on the femoral condyles, resulting from a disparity in the action of the anatomic structures which normally maintain these bones in proper relation. There are two distinct elements in the deformity, i.e., lateral deviation of the tibia on the femur and external rotation of the tibia. Whitman[2] calls attention to this feature in adolescent rickets: "In addition to the direct deformities of the bones there is a change in the relation of the femur to the tibia. The former is rotated inward and the latter is rotated outward. . . . When the limb is fully extended the deformity is most marked, because the shortened ligaments and tissues on the outer aspect of the joint become tense. . . . As the leg is flexed the deformity lessens and in the attitude of complete flexion it disappears." (Whitman.[2])

The teaching most generally accepted regarding rotation at the knee-joint might be summarized as follows: Rotary movements take place only in flexion, the maximum being thirty-six degrees and occurring when the knee is in about one hundred and fifty degrees of flexion. The chief internal rotator is the popliteus, but it is assisted in this movement by the semitendinosus, semimembranosus, the gracilis, and the sartorius. The biceps is the only muscle mentioned as being an external rotator. It is believed that the short head of this muscle arising from the femur gives it a decided advantage as a rotator. In flexion, all ligaments except the anterior crucial are relaxed and hence take little or no part in stabilizing the joint in this position. The crucials exert a minor influence in checking rotation. In the event of complete paralysis of all of the internal rotators and of the quadriceps with the biceps normal, it is more than likely that a flexion deformity plus outward rotation of the tibia would eventually result, even without the added influence of weight-bearing or any posture which might tend to increase such a deformity. But this deformity has been repeatedly observed where the grouping of paralyzed muscles was such that its development could not be explained on the simple principle of muscular imbalance. Under such conditions postural influences must be paramount, the rotation being due to a pathologic contracture and not merely to overaction of the external rotators.

If one attempts to correct paralytic knock-knee manually it is found that it can be most easily and completely accomplished by first abducting and flexing the hip and in addition, as Whitman has pointed out, by flexing the knee. In this position all deforming structures tend to relax, and in cases of moderate severity the rotation can be completely corrected. If, now, the hip is adducted and extended at the same time, the knee still

FIG. 7

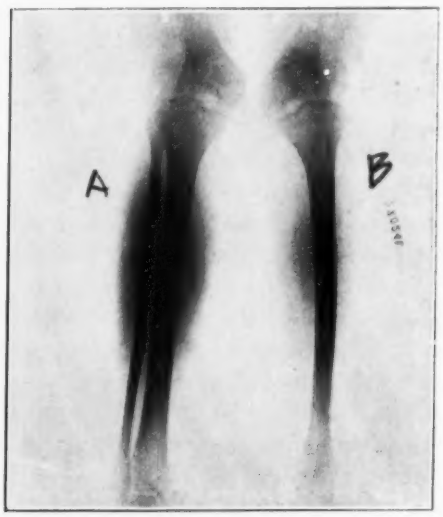

FIG. 8

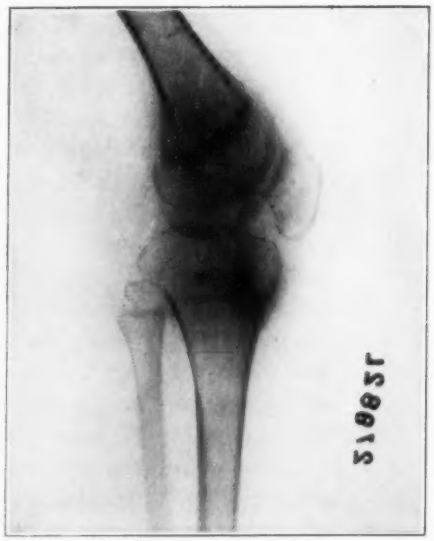

FIG. 9

Paralytic knock-knee. There is practically no bony change, but the change in relation of the bones of the joint is striking. Lateral deviation as well as rotation is evident. Rotation is so marked that in an antero-posterior view of the knee-joint the bones of the leg (lower third) show as in a lateral view (Fig. 8), and in a lateral view as in an antero-posterior (Fig. 9).

being flexed, it will be seen that definite resistance to the correction of rotation at the knee is felt, and that the prolongation of the ilio-tibial band to the head of the tibia is the structure which is offering the resistance. In well-marked cases this structure can be clearly seen and distinctly felt, not only above the outer condyle, but between it and the head of the tibia as well. If now the knee is extended, it will be noted that additional resistance, especially to internal rotation, is offered and that the outer hamstring becomes proportionately more tense than the internal group as the extension

FIG. 10

Rachitic knock-knees. Predominant pathology is bony. There is practically no displacement of joint surfaces.

is increased. This indicates that the ilio-tibial band with the muscles activating it and the outer hamstring are both important factors in the deformity. While it is not contended that the gluteus maximus and the tensor fasciae femoris are normally external rotators of the tibia, yet when in a state of contracture there is no doubt that they act to produce this deformity both independently and in conjunction with the biceps. In estimating the influence of a given muscle in a state of pathologic contracture as a factor in a deformity of a joint, one cannot adhere to the hypothesis that that muscle will produce deformity only in the direction of its normal physiologic action. Have we not shown that the hip abductors are

chiefly responsible for the production and maintenance of a pseudo-hip flexion contracture? On this basis it is maintained that the tensors of the fascia lata when in a state of contracture may be effective in producing external rotation of the tibia, though normally they have no such action. The fact that this deformity has been observed in the presence of an acting quadriceps and without a flexion contracture would seem to eliminate the biceps as a factor in certain instances and prove the independent action of the tensors, particularly so since simple fasciotomy of the ilio-tibial band is effective in correcting the deformity under these conditions. The contracted fascia lata is mainly responsible for direct lateral deviation of the tibia on the femur, but is also in part responsible for rotation in conjunction with the overaction of the biceps when the knee is flexed. Adaptive shortening of the fibrous portion of the capsule and of the ligaments on the outer surface of the joint offers a certain amount of resistance to correction in long-standing cases, but is surprisingly unimportant in the average case. Actual distortion of the bony contour of the joint, though it exists to a moderate degree in many cases, is not sufficient to be a factor in preventing correction or causing recurrence if the distortion of the soft parts has been removed. Marked tibial torsion has been observed in those cases in which the deformity was unilateral and in which weight-bearing was possible on the affected limb.

THE IMPORTANCE OF ANATOMIC CONSIDERATIONS ON THE PLAN AND METHODS OF TREATMENT

Briefly the anatomic considerations which have a practical bearing on the treatment of hip flexion, knee flexion, and knock-knee as seen in anterior poliomyelitis are the following:

1. The tensors of the fascia lata (a portion of gluteus maximus, tensor fasciae femoris muscle) are usually the most important deforming factors in hip flexion contracture.

2. By reason of the joint continuation of the gluteus maximus and the tensor fasciae femoris as the ilio-tibial band to be inserted into the head of the tibia, these muscles when in a state of contracture exert a marked influence in the production of "knock-knee."

3. The biceps is frequently an important factor in the production of external rotation of the leg in the presence of knee flexion contracture.

4. The sartorius plays no part in hip flexion contracture.

In this clinic* simple subcutaneous fasciotomy of the ilio-tibial band

*Allegheny General Hospital.

has been more frequently used in these cases than any other surgical procedure. A fair number have been treated according to the method of Soutter, and still others by simple postural stretching. Observation of results following these various methods has convinced us that, except in those cases in which the deformities are of long standing and of marked degree, better final results are obtainable with division of the ilio-tibial band at the knee than with any other method of treatment. The dual rôle of the tensors of the fascia lata in producing conjointly the deformities of hip flexion and knock-knee is a matter demanding special consideration from the standpoint of method of treatment. Since beginning the study of this particular group of patients no case having a flexion contracture at the hip and knee has been observed in which there was not some lateral dis-

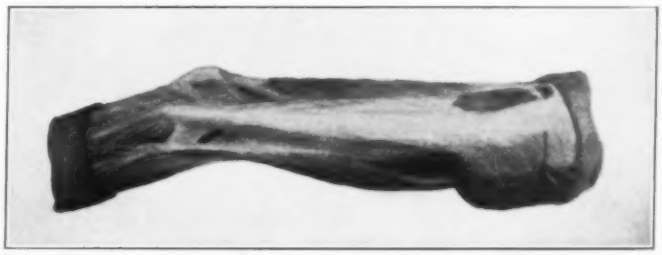

FIG. 11

Drawing from fresh dissection.

The muscle fibres of the gluteus maximus blended with the fascia lata. A large part of the power of the gluteus maximus is exerted upon the fascia lata and through it upon the tibia. The main insertion of the ilio-tibial band is into the tibia.

tortion at the knee-joint. By division of the ilio-tibial band the contracture of the tensors is relieved in such a manner that it is effective in initiating the correction of both hip flexion and knock-knee. The power of the muscles acting on the ilio-tibial band is only temporarily impaired, as the gap resulting ultimately fills in with scar tissue as in the usual tenotomy; the cutting is done in tissues of low vascularity and there is consequently little hemorrhage and usually no post-operative shock. In the method of Soutter in which the muscular origin of the tensor fasciae femoris, as well as the sartorius, is stripped free, hip flexion only is influenced directly, the knock-knee being unaffected because the zone of correction is so remote from the seat of the deformity and also because the intermuscular septa arising from the fascia lata, which are so intimately connected with the

FIG. 12

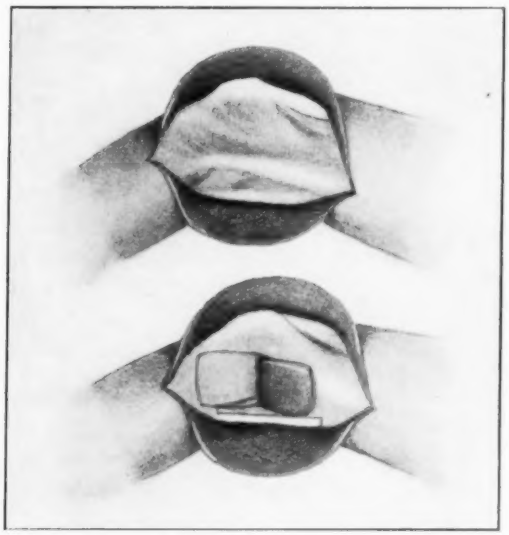

FIG. 13

Subperiosteal stripping of the insertion of the ilio-tibial band and Z-tenotomy of the biceps tendon.

Fig. 12. Incision.

Fig. 13 (top). The dissection of the skin dorsally need not be carried beyond the upper edge of the ilio-tibial band. Exaggerated here for descriptive purpose.

Fig. 13 (below). The incision through the fascia is made through the periosteum. The subperiosteal stripping is carried up to the joint crevice. The Z-tenotomy of the biceps tendon should be as long as possible.

ilio-tibial band, prevent any appreciable amount of correction of the knee deformity. In this operation it is believed that the sartorius is attacked unnecessarily. It has seemed in a few cases that the Soutter method has been in a measure harmful in weakening an active gluteus maximus. The explanation offered for this is that the portion of the gluteus maximus which is inserted into the fascia lata and presumably acts as a tensor of the fascia lata is weakened to a degree commensurate with whatever impair-

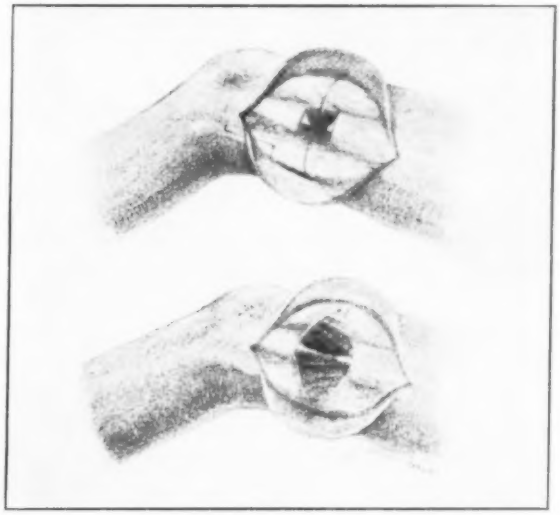

FIG. 14

Division of ilio-tibial band and the intermuscular septum through open incision.

(Top) Ilio-tibial band, proper, divided. Line of tenotomy of biceps indicated.

(Below) Intermuscular septum divided and stripped free from bone for about one cm. Fascia lata divided beyond the band, laterally and mesially.

ment of power results from the severance of the origin of the main tensor of the fascia lata, i.e., the tensor fasciae femoris.

Recently an opportunity was offered to study post-mortem the effect of division of the ilio-tibial band in a patient who had died from other causes ten days after operation. At the autopsy the outer lower third of the right thigh was exposed by laying back a large flap, and the operated area was examined. The band itself had been successfully divided and there was a small amount of clotted blood at the site of division. Upon

forcibly adducting and extending the hip the edges of the incision separated about two centimeters and upon forcibly correcting the external rotation of the knee, which could be readily accomplished with moderate force, the distal lip of the wound became tense and separated about one centimeter more. The fascia lata was then more widely severed and the wound deepened to the bone in order to more clearly observe the intermuscular septa. These structures were seen to become tense in opposite directions on each side of the incision when force was used to correct hip flexion and knock-knee simultaneously. It was apparent that the amount of immediate correction possible was limited by the lateral expansion of the fascia lata and by the intermuscular septa. Considerably more correction was possible after having broadened and deepened the incision.

PLAN OF TREATMENT IN VARIOUS DEGREES OF DEFORMITY

1. Postural stretching without operation should be limited to those cases of hip flexion in which there is neither knee flexion deformity nor knock-knee. It is important that the knees be kept extended during the correction of the hip flexion in order to prevent the distorting action of the tensors on the knee.

2. Simple subcutaneous division of the ilio-tibial band at the knee is considered advisable even in mild degrees of deformity in cases where all three deformities are present, as the time required for complete correction is materially shortened and the distorting action of the tensors on the knee is removed. In the post-operative stretching it is important that the knee flexion be corrected slowly by wedging in casts. The wedging should be done in such a manner that the leg will tend to be bowed as the extension progresses. In addition the cast should be cut circularly just below the knee and the leg forcibly internally rotated two or three times during the correction of flexion, the correction being maintained by reinforcing with additional plaster bandages. It is considered inadvisable to attempt forcible correction at the time of operation on account of the danger of increasing the outward rotation of the tibia on the femur, which would result from the disproportionate resistance offered by the biceps. In young children (under six years), even when the deformities are of extreme degree, more radical treatment than simple fasciotomy at the knee is unnecessary.

3. When all three deformities are present in children over six years of age or in adults, a somewhat more radical procedure is advisable. The ilio-tibial band proper should be completely divided, and in addition

the fascia lata should be cut laterally as far as the biceps tendon and mesially to the middle of the anterior surface of the thigh. The severance of the fascia lata on the outer surface is more important because the external intermuscular septum which passes between the vastus externus and the biceps is the stronger, and by reason of its lateral position is more effective in resisting the corrective movement which is being sought, i.e., adduction. The section of the band and the fascia lata should be made approximately one inch above the proximal border of the patella. At this point the band stands out distinctly between the tendinous portion of the vastus externus and the biceps. The vastus externus turns in sharply to be inserted into the outer border of the patella, leaving a distinct sulcus between it and the ilio-tibial band. The biceps is tendinous at this point and can be easily distinguished. Between the vastus internus and the biceps tendon there are no structures of importance except the ilio-tibial band, so that one can deal with the latter radically without danger to other structures. One case in which this procedure had been attempted by the closed method was observed subsequently through open incision. The section had not been sufficiently thorough. Open incision is preferable and should be directly over the band in the long axis of the limb. Transverse incision of the skin gives better exposure, but there is danger of tension and separation in the subsequent correction. If the knee flexion and knock-knee are marked, the biceps should be exposed and lengthened in a similar manner to the Beyer tenotomy. Having severed the two structures which act to produce the deformity it would seem that the internal hamstrings which are also contracted would tend to internally rotate the tibia as the knee was extended in the subsequent wedging, thus automatically correcting external rotation. In the more resistant cases multiple subcutaneous fasciotomy of the fascia lata higher up the thigh will be of value in shortening the period of post-operative stretching, but is not essential.

4. Two cases have been observed in which there was very marked deformity at the knee without any flexion deformity at the hip. In each of these cases there had been a well-marked hip flexion deformity which had become slowly and completely corrected after the patients were able to get about on crutches. (Cases II and III.) In both instances the hip flexion was corrected by ambulation and the knee deformity increased. The probable explanation of this is that the contracted structures at the hip were slowly stretched by the suspended weight of the entire lower extremity. The increase in the knock-knee is probably due to several factors: First, vertical suspension of the limb would tend to

correct the flexion deformity at the knee, but owing to the over-contracted condition of the biceps, as the knee was slowly extended, the biceps would act to increase external rotation. Second, the correction of flexion at the hip was probably obtained in part at the expense of additional external rotation at the knee due to the action of the tensors on the head of the tibia. Third, the added strain of even partial weight-bearing would probably tend to increase the deformity and especially so in view of the fact that the thigh was abducted and externally rotated and the foot markedly everted in each. A moderate amount of tibial torsion was present in both. In one of these cases the deformity at the knee-joint with the accompanying instability was the chief factor preventing the use of the limb in functional weight-bearing. As the operative measures previously described did not seem to meet the indications in this case, the following more radical method was used: A curved incision was made beginning three and one-half inches above the joint over the biceps tendon, passing dorsalward and downward over the ilio-tibial band, outer border of the patella, and one-half inch below the tubercle of the tibia, ending on the outer surface of the leg just below the head of the fibula. The flap was reflected laterally, exposing the fascia lata and the biceps to the points of their attachments below the knee. The joint was fully flexed and then an attempt was made to correct the lateral deviation and external rotation of the tibia. The ilio-tibial band and the lateral part of the joint capsule and the contracted lateral ligaments offered resistance, but the deformity could be almost completely corrected with the knee in acute flexion. As the knee was extended all of these structures and the biceps became tense and pulled the leg into the deformed position. The biceps tendon was first lengthened as previously described. All ligamentous structures and the attachment of the ilio-tibial band were then freed by subperiosteal stripping from the head of the tibia, beginning at the tubercle of the tibia and extending upward to the top of the bone. The portion of the external lateral ligament attached to the head of the fibula was freed in like manner. The knee was then forcibly extended and internally rotated. It was possible to extend approximately 25 degrees more than before and to fully correct external rotation and lateral deviation. Resistance to extension was still offered by the internal hamstrings, and no attempt was made to overcome this for reasons previously stated. A cast was applied with the knee flexed at 140 degrees, at which point the lateral deviation and external rotation could be completely corrected. Wedging was not started until three weeks after operation, when the skin incision was healed.

The knee was wedged into slight hyperextension with little or no pain in about ten days.

In spite of the fact that normal relations had been restored at the knee-joint, the foot remained everted with relation to the knee about 20 degrees. This, of course, was due entirely to the lateral deviation of the malleolar mortise from tibial torsion and was correctible by osteotomy of the tibia. The correction of this foot deviation was considered important, as it constituted a powerful predisposing factor in the recurrence of the knock-knee, especially so in the presence of a knee which was potentially weaker on its inner surface.

5. In those cases in which the quadriceps is paralyzed and the tensors of the fascia lata are active the advisability of utilizing the latter as extensors of the knee suggests itself. Spitzy has devised and used rather extensively an operation for utilizing the tensor fasciae femoris muscle for this purpose. In this operation no consideration is given to the fact that a fair portion of the gluteus maximus functions as a tensor of the fascia lata and acts conjointly with the tensor fasciae femoris muscle by means of its fusion with the latter in the ilio-tibial band. With this in view the operation has been modified to the extent that instead of stripping free a narrow portion of the fascia lata, up to the muscular insertion of the tensor fasciae muscle, a broad fan-shaped section of the fascia lata is included, the broad part being taken from the lateral and posterior surface, the dissection extending up to the lower edge of that portion of the gluteus maximus which is inserted into the fascia lata. One case in this series has been treated in this way. Sufficient time has not elapsed to warrant an estimate of results. If that portion of the gluteus maximus which acts as a tensor can thus be successfully utilized as an extensor there would seem to be little doubt regarding the value of this procedure.

In those cases in which both groups of hamstring muscles are acting, the transference of the biceps with the tensors as described would probably give the best obtainable results from tenolysis for paralysis of the quadriceps.

CASES

Case I. M. B. Anterior poliomyelitis at eight years of age.
Muscle analysis on admission:
Hip— Adductors—nil.
Flexors—fair minus.
Extensors—fair plus.
External rotators—fair.
Internal rotators—poor minus.

Knee—Inner hamstrings—good.
Outer hamstrings—good.
Quadriceps—nil.

Deformities:

1. Hip flexion—Analysis.

(*a*) Extremity in sagittal plane with knee flexed (limit of extension) at 120°, hip could be extended to 135°.

(*b*) Extremity abducted 30°, hip could be extended to 180°. As thigh was adducted flexion gradually increased to 135° when in sagittal plane.

2. Knee flexion and knock-knee.

Knee could be passively extended to 120°.

It was noted upon fully flexing the hip and knee-joint that the lower leg could be rotated inward on the femur, but when the hip was extended and the knee extended the lower leg was held rigidly in the knock and externally rotated position and it seemed that this position was maintained by the tensor fasciae femoris mostly and that only on extreme extension of the knee-joint did the outer hamstrings seem to be a factor.

3. Foot—Talipes equino-varus (marked).

Closed subcutaneous division of the ilio-tibial band one inch above the knee-joint was done under gas anaesthesia (5 min.). A moderate amount of force was used in the direction of extension (hip). The degree of contracture was diminished 10° (estimated). By flexing the knee to 120° the lateral deviation and external rotation could be almost completely corrected. With the knee at this angle it was forcefully internally rotated and bowed. A cast was applied with the extremity in the sagittal plane. The hip was flexed at 135° and the knee at 120°. The knee was held in such manner that the lateral deformity was largely overcome at this angle. The foot was moulded into slight valgus and was included in the cast. The cast was cut circularly at the hip and a metal bar with a joint was incorporated on the outer surface.

The patient was placed on a frame in the Soutter position, the hip stretching being started at once. Wedging for correction of knee flexion was started on the third day post-operative. Correction of hip and knee flexion was complete twenty-eight days after operation, but a slightly over-corrected position was maintained one month longer. This case is cited as one of average severity, showing the combined hip and knee deformity, both elements of which are readily correctible by simple subcutaneous division of the ilio-tibial band.

Case II. J M. Male. 18 years.

Anterior poliomyelitis at 14 months of age. There was extensive paralysis involving the back muscles and both lower extremities. About one year after the acute illness the patient was able to sit up and to creep, but with great difficulty. He had not been able to walk except with crutches, and in his manner of progression with crutches no weight whatever was borne on his feet. In order to stop in the erect position it was necessary to seek more support to lean against. Hip flexion, which doubtless was present prior to the time when he began to walk with crutches, was not present at the time of admission to the hospital. Both knees were flexed; the right to 130°, left to 140°. When leaning on his crutches with his legs suspended, an extreme degree of lateral deviation and external rotation of the tibia on the femur was apparent. The ilio-tibial band and the biceps tendon stood out prominently. The amount of external rotation was approximately, right 40°, left 35°.

This case was interesting and instructive in view of the fact that a very extreme knock was present in the absence of hip flexion and with only a moderate degree of knee flexion. The influence of ambulation in correcting hip flexion and knee flexion with coincident increase in the rotation deformity at the knee is conclusively shown in this case. The method of operative correction chosen in this case was by subperiosteal stripping of the insertion of the ilio-tibial band and tenotomy of the biceps as described in the text. Satisfactory correction of the knee deformity was obtained.

CASE III. F. R.

The early history of this case was similar to that of Case II, and the deformity was likewise similar as regards the absence of hip flexion contracture in the presence of an extreme rotation deformity of the right knee-joint. The latter deformity was more marked than in Case II and was complicated by outward dislocation of the patella. About one-third of the lateral portion of the vastus was acting. It is believed that the action of this structure in conjunction with that of the ilio-tibial band was responsible for the dislocation of the patella. The operative method used in this case was the same as that used in Case II with the following modifications:

The incision extended to the upper third of the outer surface of the thigh. After having stripped free the insertion of the ilio-tibial band from the tibia the dissection of the band was carried up the thigh and included that portion of the vastus externus which was active. Above the ilio-tibial band proper a strip of fascia lata about two inches wide was freed This was allowed to broaden as the dissection was carried up so as to include at the base of the strip all of the fascia lata into which the gluteus maximus and the tensor fasciae femoris are inserted. The patella was replaced and held in position by plication of the redundant structures on the inner surface of the knee-joint. The strip of fascia lata including a portion of the vastus externus was then transplanted to the center of the thigh and fixed to the patella as described by Spitzy.

The post-operative wedging of the knee, which was not begun until three weeks after operation, was done slowly. Very satisfactory correction of the knee deformity was obtained. Sufficient time has not elapsed to estimate the value of the tenoplastic procedure.

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DISCUSSION

Dr. Charles W. Peabody, Detroit: Dr. Yount is to be complimented on his able exposition of the anatomic and physiologic principles governing the effect of this structure on the hip, the principles upon which Dr. Soutter's operation was based years ago and which have been pretty well accepted by most orthopaedic surgeons. I can recall two cases which seem to bear out Dr. Yount's observation regarding the knee. Both were individuals with spastic paralysis, on whom appropriate operations on nerve and other structures had remedied difficulties in the hip and foot, but in both knock-knee persisted, with also a rotation outward of the leg at the knee. The gait and attitude seemed almost positively to indicate a bony deformity for which an osteotomy might be done, but the roentgenograms did not show any skeletal deformity and the spastic contracted ilio-tibial band was considered responsible.

In one patient a simple tenotomy of this structure was performed, with marked satisfactory immediate results. However, in a year there was a beginning of a recurrence of the contracture. In the second case a distinct plastic operation was done on this band, insuring adequate relaxation without possibility of subsequent contraction of scar tissue. The relief afforded by this procedure has been permanent after three years.

Dr. David Silver, Pittsburgh, Pa.: I wish merely to emphasize some of the points Dr. Yount has made. As he has said, for the last four or five years in the Orthopaedic Clinic at the Allegheny General Hospital I have been treating this type of flexion deformity of the hip by subcutaneous division of the fascia lata at the knee. A sufficient number of cases have been followed to enable me to feel very certain that the results obtained by this trifling procedure are just as good as by any other method: the amount of correction secured by the operation itself is just as great and there has been no more tendency to relapse.

Dr. Yount's very clear demonstration of the part played by the fascia lata in paralytic rotation deformity of the knee appears to me to be a new and valuable contribution. I have had the opportunity of seeing most of the cases upon which he has operated and the results have been thus far all that could be asked.

BEHAVIOUR OF SEQUESTRA IN CHRONIC OSTEOMYELITIS*

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Fellow of the C.R.B. Educational Foundation

EXPERIMENTAL WORK ON RABBITS†

Experimentation has been a necessity to satisfy and coördinate the views of investigators and progressively has become the only basis of scientific work, but as Mallory says, "Recourse to animal experimentation has often served to confuse a subject rather than to simplify and clear it up." This is what happened in the investigation on chronic osteomyelitis. Duhamel, Ollier, and Macewen's experiments have been partially misinterpreted,—or better, have perhaps been applied too largely to human beings. From these experiments have grown the different ideas about treatment in bone injury and bone infections. Radicalism after many failures has led surgeons to rather more conservative means in treatment.

The behaviour of the sequestra in chronic osteomyelitis is the leading basis for its treatment.

The experiments before the era of aseptic surgery (Gulliver, Savory, Gmelin, and Busch) are well known, but cannot be quoted any longer; the pathology of osteomyelitis was unknown at that time. What Gulliver wrote a century ago is still applicable at this time: "Perhaps there is no subject in surgical pathology which has been more diligently investigated than that of necrosis." It is, therefore, not surprising that numerous methods of treatment have been advocated, but those who have examined these different methods must have perceived how widely they differ from each other.

Lately a few authors on a clinical and experimental basis have resuscitated the idea of more and more conservatism. Professor A. Bier[1] (1921), in treatment of bone tuberculosis with sequestra, and on sequestra due to secondary infection, applies the same conservatism and advocates the abandonment of any surgical means.

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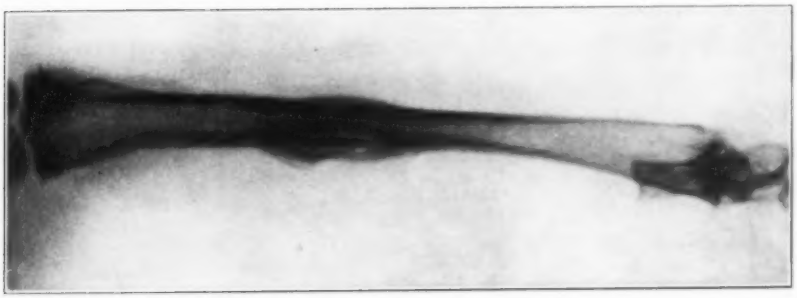
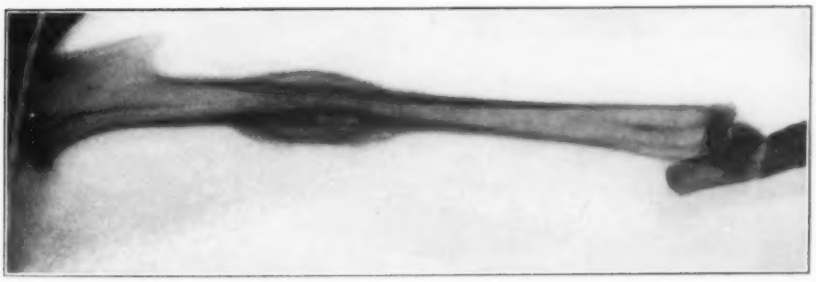
† These experiments were started in January, 1922, by Dr. Peremans and carried further by Dr. William Rogers.

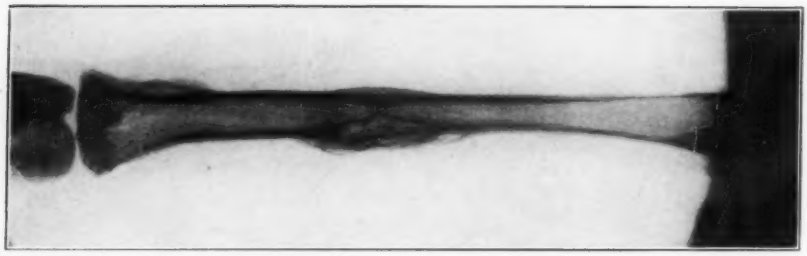
CASE I. FIG. 1. Oct. 15, 1923



CASE I. FIG. 2. Jan. 14, 1924

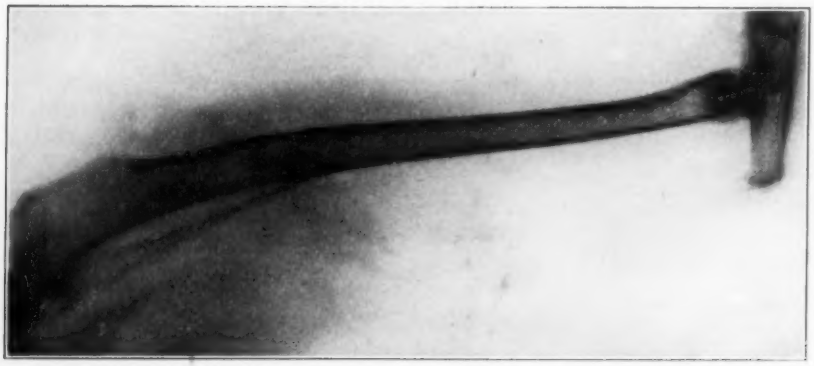


CASE I. FIG. 3. Feb. 11, 1924

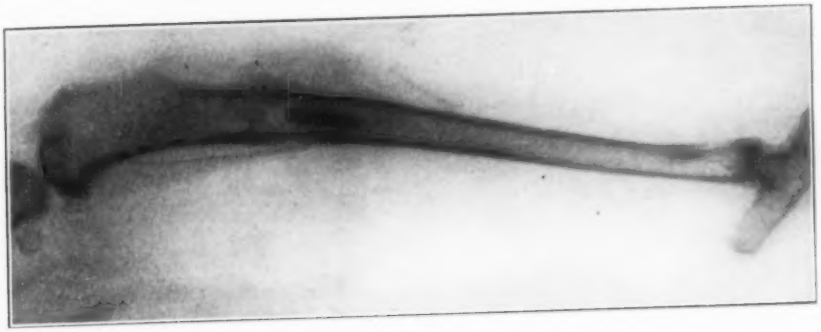


CASE I. FIG. 4. Aug. 23, 1924

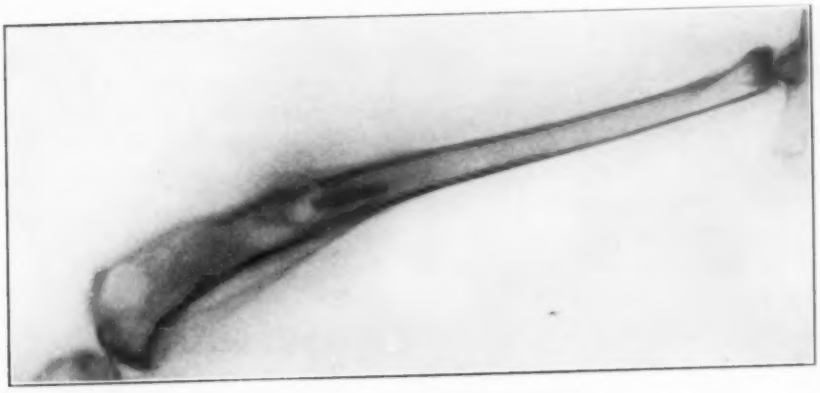
CASE I. FIG. 5. Oct. 25, 1924



CASE II. FIG. 6. Sept. 17, 1923



CASE II. FIG. 7. Oct. 6, 1923



CASE II. FIG. 8. Oct. 15, 1923

CASE II. FIG. 9. Dec. 15, 1923

Professor C. L. Starr[2] has carried out some experiments in reproducing osteomyelitis in animals, using chemical means. He succeeded in demonstrating the process of destruction and sequestration. In 1919, F. W. Bancroft[3] attempted to follow the absorption of the sequestrum produced by chemical means, and reports a gradual disappearance of the former sequestra which became impossible to detect by roentgen ray at the end of two months. His microscopic studies showed the disappearance of the zone of separation, and the former sequestrum was then united to the living bone by blood vessels entering the Haversian canals. He said, "All the factors of an acute osteomyelitis were present with the exception probably of bacteria and their by-products."

At the suggestion of Dr. R. B. Osgood we have resumed the investigations, adding "bacteria and their by-products."

TECHNIQUE: Young rabbits were used as experimental animals. As bacteria, staphylococcus pyogenus aureus and albus, obtained from blood cultures, or pus of acute osteomyelitic cases: a colony of these bacteria was embedded in agar-agar. As artificial sequestrum a piece of rabbit's bone about 10 mm. in length and 4 mm. in breadth, boiled for an hour, was used. Under aseptic conditions a hole was drilled in the metaphysis or near the upper end of the diaphysis of tibiae or femora; the sequestrum and a colony of bacteria laid in; the periosteum sewed over, and the skin closed in several layers; sterile dressing. Weekly roentgenograms were taken to follow up the behaviour of the artificial sequestrum.*

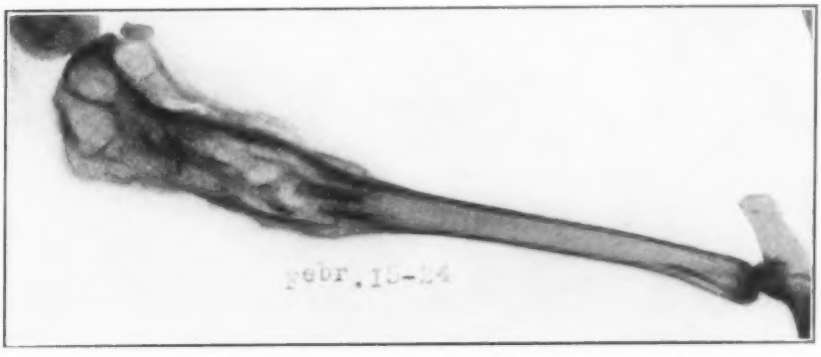
We will report a few results of our experiments. A typical picture of osteomyelitis may be obtained by this method. The first X-ray signs of a typical osteomyelitis show eleven days after operation. There are some areas of destruction seen in the cortex. Later on the destruction progresses gradually, the periosteum is elevated, the marrow cavity is obscured, the bone has a "spotty" appearance (See figures of Rabbit 6), infection spreads through the entire bone, a part of the shaft sequestrates, and under the periosteum a layer of new and dense bone appears. We

* 1. We have used rabbits because there exists a certain immunity in these animals against staphylococcus infections, thus preventing staphylococcic septicemia (that which killed Starr's dogs).

2. The artificial sequestra came from other rabbits, but as they were boiled for one hour no biologic objections could be made.

3. The sequestra were used purposely, although it is possible to produce sequestra in infecting bone locally by organisms, or by injuring the bone and intravenous injection of these organisms. Ollier pointed out, more than fifty years ago, the use of a probe to detect sequestrum is unreliable as proof of the *complete* separation. Actually roentgenography is also unable to give us accurate account of the separation. (We have all of us chiselled from healthy bone the sequestra which seemed detached and well outlined in radiograms.)

have obtained various degrees of osteomyelitic processes—mild forms with localized infection, several forms with large abscess formation involving partially or totally the medullary cavity, expulsion of sequestra, etc. If no artificial sequestrum is used we remain in the same ignorance of the complete separation of the spontaneous sequestra seen in the roentgenograms. When fractures occur after operation the callus formation prevents us from following the gradual disappearance of the sequestra.



CASE II. FIG. 10. March 22, 1924

CASE REPORTS

CASE I. Example of osteomyelitic process—mild form.

Rabbit 5.

September 7, 1923. Operation. A colony of staphylococcus aureus embedded in agar-agar and a small sequestrum, 6 mm. long, were introduced in the upper third of the shaft of the right tibia.

September 18, 1923. Roentgenograms do not show any sign of infection.

October 6, 1923. Soft part swelling around the shaft, marked periosteal reaction, the cortex is intact, the artificial sequestrum unchanged.

October 15, 1923. (One month and seven days after operation.) The soft part swelling is fluctuant, the abcess is incised, the examination and cultures of the pus show staphylococcus aureus. The periosteal reaction seen—the sequestrum seen above the drill hole.

October 30, 1923. A part of the cortex at the region of infection became sequestrum; the demarcation at its lower end is evident.

November 6, 1923. The soft part swelling is gone, the wound is healed, the artificial sequestrum is getting smaller.

January 14, 1924. The disappearance of the artificial sequestrum is complete, periosteal reaction around the infected area, well outlined sequestrum present. The successive roentgenograms show all the same picture with persistence of the seques-

trated cortex. The radiograms from that time on reveal a slight but gradual disappearance of the sequestrum.

October 25, 1924. A film taken post mortem shows an absorption of the sequestrum. No examination was made to reveal the presence or absence of organisms in the bone.

CASE II. Example of osteomyelitic process—severe forms.

Rabbit 6.

September 17, 1923. Operation. Large artificial sequestrum, 11 mm. long, introduced in the marrow cavity of the right tibia, upper third. A colony of staphylococcus aureus embedded in agar-agar is introduced at the same time. The roentgenogram on September 18 showed the sequestrum in place.

October 6, 1923. Slight reaction of the periosteum, an area of destruction in the cortex above the drill hole, and some swelling of the soft parts.

October 15, 1923. The upper third of the tibia has a "spotty" appearance, large areas of destruction are seen in the cortex, the reaction of the periosteum is intense, the swelling of the soft parts is increasing.

October 18, 1923. The soft part swelling is very tense and breaks down.

December 15, 1923. The entire upper third is invaded; the artificial sequestrum remains unchanged. New bone formation is very markedly seen. A new small sequestrum is present just above the artificial sequestrum, the cortex is very thin, multiple abscesses are breaking down, leaving sinuses; no sequestra are eliminated. The cultures of the discharging pus give staphylococci.

March 22, 1924. The picture is the same as on February 15, 1924.

May 13, 1924. All the sinuses are healed; large indurated masses are present. The radiograms up to January, 1925, continue to show the same picture. A roentgenogram taken post mortem shows the following features: Indurated masses in the soft parts, huge proliferation of the periosteum, no real involucrum formation, spotty appearance of the cortex with a large amount of destruction-obliteration or absence of the medullary cavity, artificial sequestrum practically unchanged.

CASE III. Example of very severe osteomyelitic process.

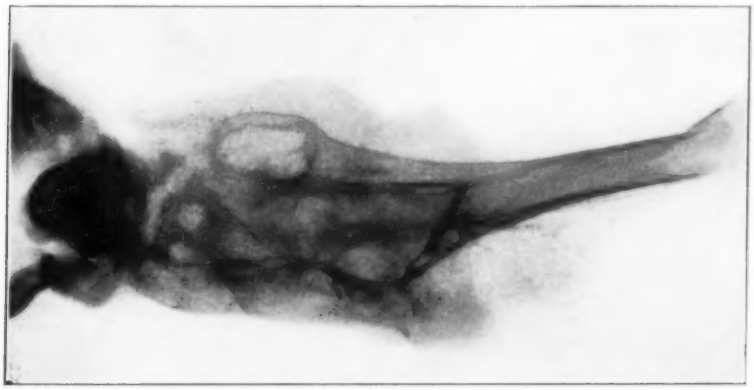
Rabbit 7.

January 18, 1924. Operation. A thin artificial sequestrum, 10 mm. long, and a colony of staphylococcus aureus imbedded in agar-agar were introduced into the medullary cavity of the distal end of the left femur. Severe infection followed. Spreading over the entire femur a huge suppuration began, involving the knee joint. As the result we noted a fracture of the lower extremity of the femur with expulsion of the artificial sequestrum and the distal part of the femur.

June 26, 1924. A roentgenogram showed the periosteal reaction (proliferation) around the rest of the femur—the gap between the femur and the tibia and small sequestra that are extruded. After this the wound closed and present condition is similar to that shown in the previous roentgenogram.

As seen in these pictures there is certainly great difference between the evolution of osteomyelitis produced by chemical means in which there is a re-incorporation of the old dead bone and in osteomyelitis due to bacteria and their by-products. The absorption of foreign material (artificial sequestrum) is extremely slow as compared with the absorption

of artificial sequestra (bone graft) under sterile conditions. These latter, as seen in control animals, disappear completely after about six months, being adherent to the endosteum during the time of disappearance. Infected sequestra are slow to disappear. In the presence of very mild infection, eleven months are necessary; in severe infection the sequestrum was still present, slightly eroded only, after fifteen months, even in practically closed infections—meaning by closed infection that there were no sinuses present for a very long time. When sinuses persist there is a continual discharge of pus and an elimination of small sequestra. An important fact is the presence of bacteria in the foci of osteomyelitis

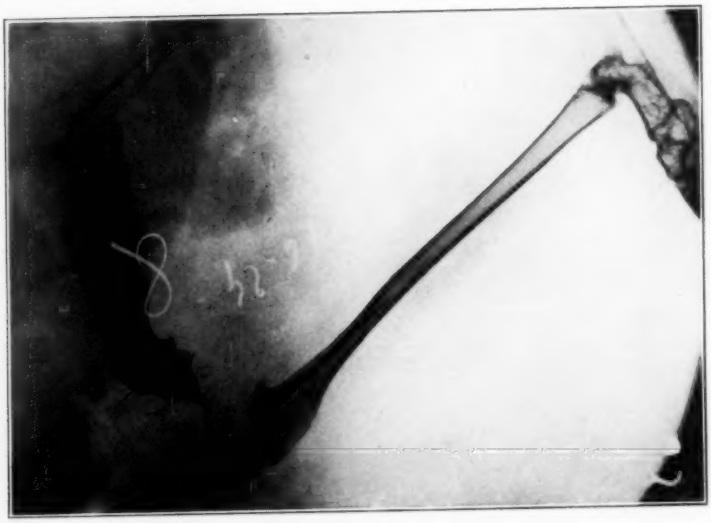


CASE II. FIG. 11. Jan., 1925

even when all sinuses are closed for at least three months. These organisms are of very low virulence, unable to reproduce osteomyelitis in other rabbits.

The microscopic examination shows (microphotograph 14, rabbit 5), a cross section of bone in the area of bone proliferation. A sequestrum is present, surrounded by pus, débris of tissue, and separated from the surrounding new bone. The sequestrum as shown in the roentgenogram has gradually diminished in size, and will disappear probably entirely, being very slowly destroyed by osteoclastic cells. No signs of live bone cells or vessels are present.

Figure 15 shows high power microphotograph of an area of Fig. 1, enabling us to show better the complete absence of any live elements in the sequestrum. The sequestrum is separated from the new bone by a



CASE III. FIG. 13. June 26, 1924

CASE III. FIG. 12. Jan. 18, 1924

line of more or less organized tissue and by pus and bone débris which is seen along the sequestrum. No cellular elements exist in this débris. On immersion there are a few osteoclasts demonstrable along the line of erosion of the sequestrum.

In Figure 16, a longitudinal section from Rabbit 4 (365 days after operation, and five months after closure of all sinuses), the sequestrum

FIG. 14. RABBIT 5

Low power photomicrograph of cross section of tibia at level of osteomyelitic focus shows sequestrum entirely surrounded by granulation tissue. A. sequestrum; B. granulation tissue; C. live bone.

was hardly seen in the roentgenogram, due to the formation of dense involucrum; the upper extremity of the fragment is seen in the section surrounded by phagocytic cells and débris of tissues; in the lower part of the section there is an active proliferation of new bone. The sequestrum is eroded and when seen under immersion many giant-cells are present, destroying this "foreign body." There was absolutely no cellular activity in the sequestrum. In the upper part of this section there is a more or less organized fibrous tissue separating this focus from the surrounding bone.

These experiments do not entirely confirm Bancroft's conclusions

Bancroft implied that completely separated sequestra, as seen in the roentgenogram, may unite to involucrum. We would point out that it is impossible by roentgenograms alone to determine whether the sequestrum is or is not completely separated, and also that Bancroft was observing the action of chemical, and not of infected sequestra. As far as

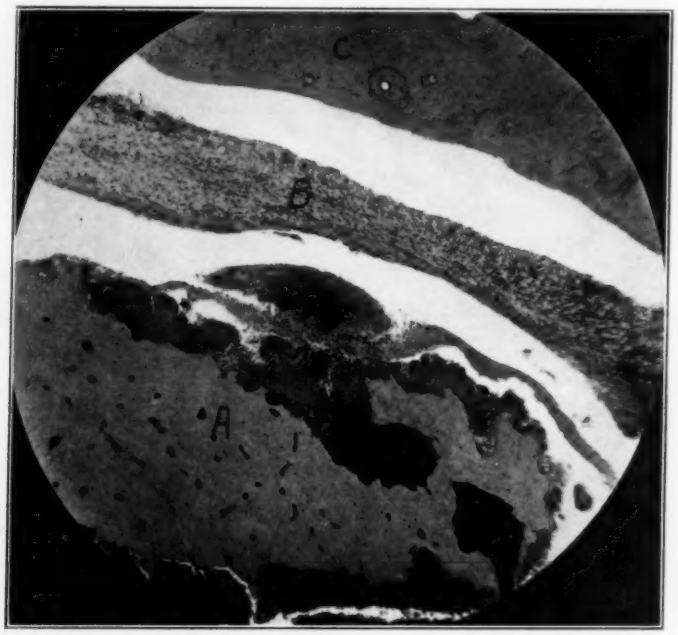


FIG. 15

High power photomicrograph taken from the section represented in Fig. 1, rabbit 5. A. sequestrum; B. granulation tissue; C. live bone.

our experimental observations go, completely separate sequestra in the presence of infection never unite to the newly formed involucrum or to the old bone. The zone of demarcation between the sequestrum and the involucrum, dead and alive, persists until complete disappearance of the former, i.e., the sequestrum. The difference lies in the conception of the sequestrum. If it is really free it must, according to our experiments on rabbits, either be absorbed or expelled. It never unites with the new or old bone.

We would caution against the formation of too many conclusions upon these experiments in animals. This is presented merely to show that nature may use many ways in getting rid of foreign bodies. The difference in her procedure depends upon the nature of their origin. Sterile bone (grafts) and infected bone (sequestra) both disappear in roentgenograms, but when examined microscopically the processes by which this disappearance is brought about are different.

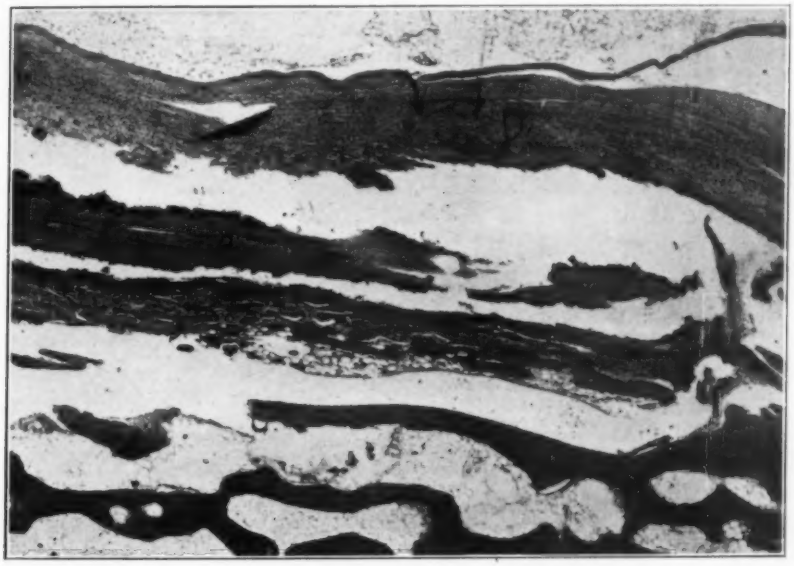


FIG. 16. RABBIT 4

Low power photomicrograph of longitudinal section of femur at the level of sequestrum implant. A. sequestrum; B. C. involucra; D. more or less organized fibrous tissue.

The general rules of pathology on foreign bodies must be applied to the behaviour of sequestra in chronic osteomyelitis.

We employed only rabbits (15) in order to have uniform conditions. Different kinds of animals may have a greater or less resistance and vitality against infections of greater or less power of regeneration.

I wish to express my sincere thanks to Dr. Charles L. Brown for the microphotographs.

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CONGENITAL ELEVATION OF THE SCAPULA

BY ROBERT D. SCHROCK, M.D., OMAHA, NEBRASKA

Proper criticism of the use of the term "congenital elevation of the scapula," is made by Greig of Edinburgh. He uses and suggests the more accurate "congenital high-scapula." In America the shorter and equally descriptive "undescended scapula" should be more acceptable. Greig's contention is based on the developmental origin of the deformity. "In an embryo of five weeks the scapula becomes differentiated opposite the fourth, fifth, sixth, and seventh cervical vertebrae; at the ninth week the scapula begins to descend from the neck of the thorax." Failure to descend gives rise to the deformity. This failure may be due to mal-development in bone, cartilage, and muscle, or the descent may be interrupted by abnormal pressure or position in utero. In the former group there are always associated abnormalities of bone or muscle. In the existing literature on this subject there may be found ample discussion of the phylogeny and ontogeny of this congenital deformity. This consideration is limited entirely to the operative treatment applicable in the moderate and severe cases.

In searching the literature for adequate information as to procedure in cases of this more severe type, only generalizations were available. The descriptions were rather indefinite and in too many the results seemed discouraging. Most of the reports indicated considerable conservatism in the operative attack. In that group presenting a chondro-osseous bridge, simple resection of the bridge was advocated by several writers. In that group with only muscle shortening, myotomies were advised. In both groups the results did not seem encouraging.

By using a far more radical procedure, but based upon the suggestions obtained from previous reports, very satisfactory results were obtained in two cases. This radical subperiosteal transplantation of the scapula with osteotomy of the base of the acromion process was not found to have been previously described. The generalizations in earlier reports have been incorporated in this concrete procedure as applied in two cases of undescended scapula with scapulo-vertebral attachment and short neck.

PROCEDURE. The incision is curved from the mid-supra-scapular region about one inch external to the medial margin of the scapula to two

inches below the inferior angle. The deeper incision is carried through the cartilaginous medial margin of the scapula with subperiosteal removal of the combined attachments of rhomboids, serratus magnus, and subscapularis. The subscapularis is completely removed. Similar subperiosteal

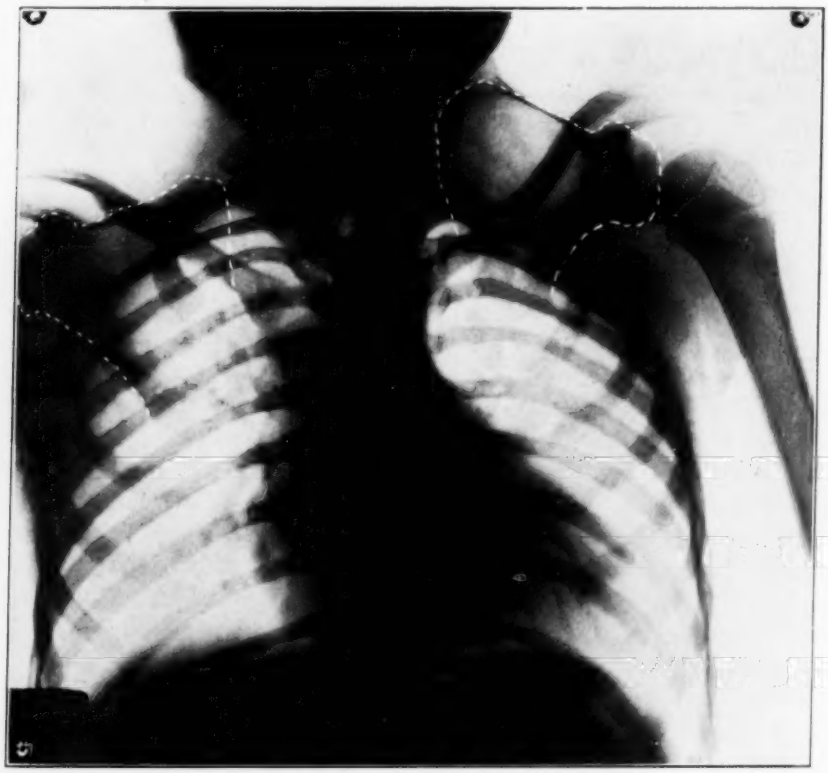

FIG. 1. CASE I
Congenital Elevation of Scapula, Left.

elevation is made of the infraspinatus, teres major and minor, completely freeing the inferior angle and lower two-thirds of the axillary border. The same procedure is applied to the insertion of the trapezius on the spine, to the supraspinatus, and to the structure of the superior margin of the scapula, using special care at the suprascapular notch. This is the only point at which there is danger to nerve or vessel of any consequence.

The chondro-osseous bridge from the vertebrae to the supero-medial margin of the scapula is removed as completely as possible. The margins of the scapula are freely removed; the supraspinous portion is resected, and much of the spine, if this be at all prominent. If the shoulder then cannot be brought back freely, an osteotomy of the base of the acromion is done.

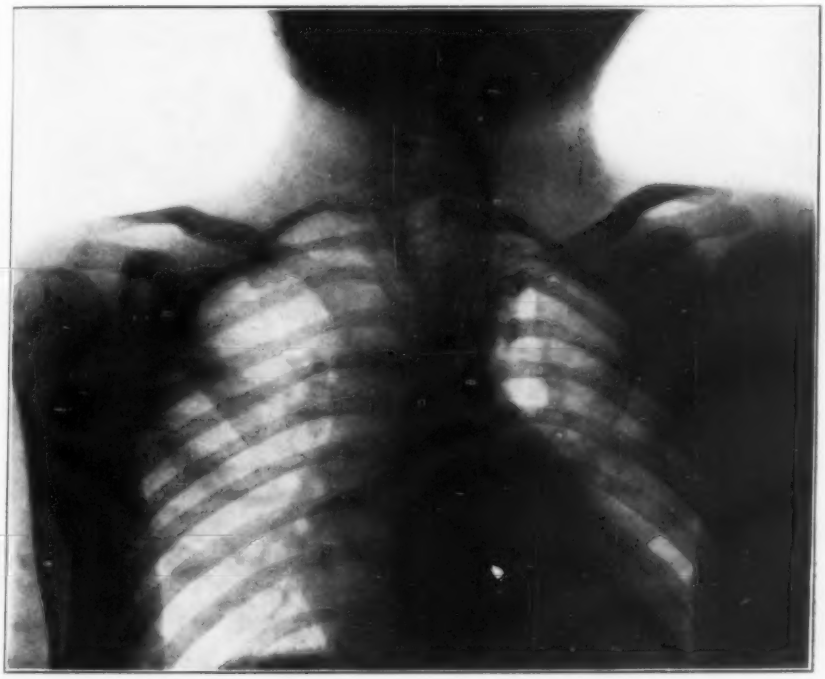

FIG. 2. CASE I

Congenital Elevation of Scapula, Left. Sixteen months post-operative.

This gives a very appreciable downward and backward drop of the shoulder. One strut of the shoulder suspension has in this way been removed. The inferior angle of the scapula is anchored with heavy chromic to the lowest rib possible. Suture of muscle layers should be made anatomic, with special care in the triangular area between the trapezius, infraspinatus, and rhomboids.

The dressing is with a pressure pad over the shoulder and long adhesive extending well down on to the trunk. This is a very important detail

and considerable downward and backward pressure can be applied in this manner. Over this is placed a figure-of-eight of the shoulders as commonly used in fracture of the clavicle.

FIG. 3. CASE I
Congenital Elevation of Scapula, Left.

FIG. 4. CASE I
Sixteen months post-operative.

CASE 1. H. M. University Hospital. Admitted December 12, 1923. Age, 6. No other congenital deformities in family. Maternal puerperium said to have been normal.

Physical examination shows a girl somewhat small for her age, well nourished, carrying her head forward and flexed. She extends upper trunk to get her line of vision on the horizontal plane. The neck is abnormally short. The head is held in some flexion

to the left. Flexion to the right is limited to one-third normal and accompanied by elevation of the left shoulder.

The left scapula is more than two inches higher than the right—definitely smaller, more oblique to mid-dorsal plane. From the upper third of the medial border, a firm mass is extending upward and attached to lower cervical spine. Motions of the scapula are definitely limited.

The left forearm and hand seem normal in contour; active abduction of the arm is limited to 90 degrees; with undue effort the hand can be placed on top of the head, but this position cannot be maintained.

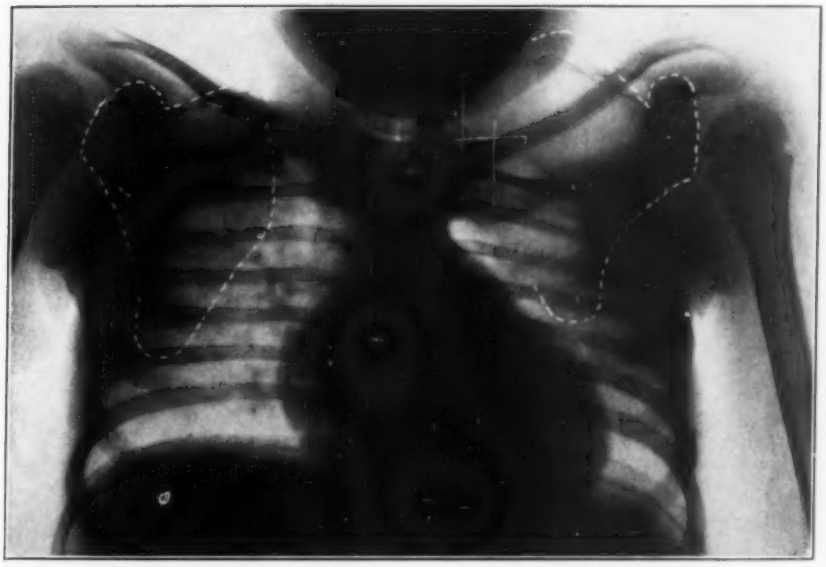

FIG. 5. CASE II
Congenital Elevation of Scapula, Bilateral.

X-ray examination shows the left scapula smaller than the right, relatively higher with its lower angle at the level of the fourth intercostal space. There is an unusual congenital abnormality in the cervical and upper dorsal spine, deficiency in number and contour of vertebrae, with failure of union of posterior laminae. The ribs are symmetrical, but only eleven on each side.

Operation: December 20, 1923. Radical subperiosteal dissection of left scapula. Resection chondro-osseous plate extending from scapula to low cervical spine. Resection curved supraspinous portion with major portion of spine. Depression of scapula three inches and anchoring with heavy chromic about rib.

Pleura was penetrated; child showed some reaction. Plastic repair of muscle layers, deep fascia, and skin.

Dressing: Fixation of dressings and shoulder in depressed position with long adhesive straps on chest, figure-of-eight, as for fracture of clavicle.

Convalescence: Moderate shock; quick recovery; on fourth day in wheel chair. Continued active use of forearm and hand. After second week allowed use of arm and shoulder; figure-of-eight dressing for four weeks.

FIG. 6. CASE II

FIG. 7. CASE II

Before Operation.

At the fourth week the left hand could be actively placed on top of the head and held for a few minutes at a time.

The result at fifteen months shows much improved position of head and neck—the shoulders practically level with abduction closely comparable to the right upper.

The improvement has been satisfactory from both a functional and cosmetic standpoint.

CASE 2. R. C. Clarkson Hospital. Admitted April 28, 1924. Age, 8. No other congenital deformities in family. Maternal puerperium reported as normal.

Physical examination shows sturdy boy; average size for his age, an apparently

short neck, very broad posteriorly. The motions of head and neck are about two-thirds normal in all planes. Moderate lordosis.

The scapulae are abnormally high; the left higher than the right. Both inferior angles are unduly prominent. Near the upper angle each scapula has a tongue-like process extending upward and medially and apparently jointed to the low cervical and

FIG. 8. CASE II

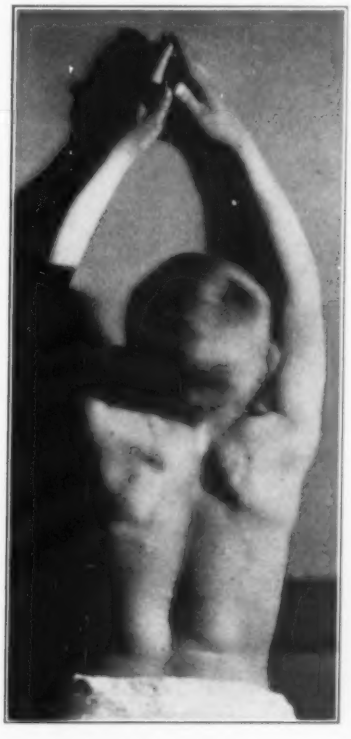

FIG. 9. CASE II

Congenital Elevation of Scapula, Bilateral.

upper dorsal spine. This process seems cartilaginous and allows motion of the scapula only by rotation about these fixed points.

The arms can be abducted to only 90 degrees; only by flexion of the head from side to side can the vertex be reached with the finger tips. Forced passive elevation of the hands brings them less than six inches from the head. The hands cannot then be approximated.

Roentgenogram shows scapulae with poorly outlined medial and superior margins; both abnormally elevated; the lower angle of the right at the level of the sixth rib; the lower angle of the left in the fourth interspace. There are six cervical vertebrae incom-

pletely developed, with spina bifida; ribs are symmetrical, but eleven on each side. There are five lumbar vertebrae with a rudimentary sixth.

Operation: May 1, 1924. Subperiosteal dissection of the left scapula; resection of cartilage plate extending from supero-medial margin to low cervical spine; resection supraspinous portion of scapula with major portion of spine; also about one inch of cartilaginous medial margin and inferior angle; depression of scapula and anchoring to rib

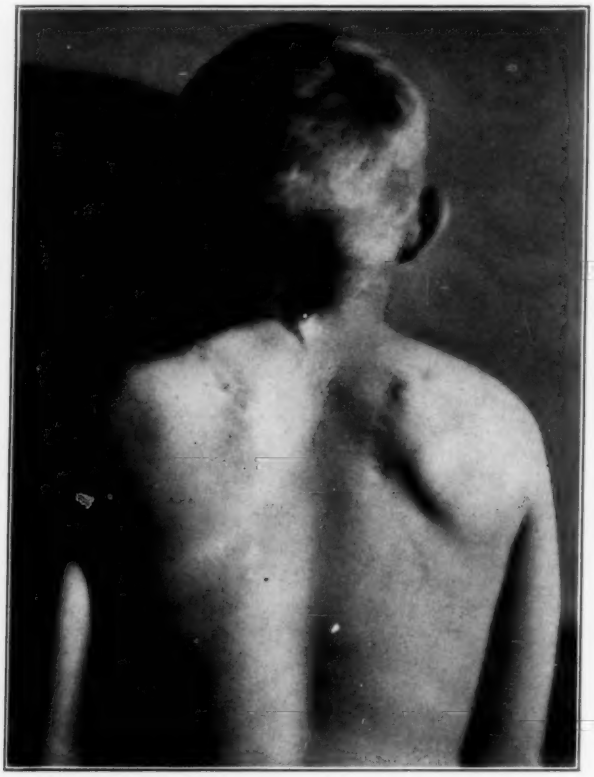

FIG. 10. CASE II

Left—Twenty months post-operative.
Right—Eighteen months post-operative.

with heavy chromic. Plastic repair in layers, adhesive dressing, and figure-of-eight of shoulders.

Convalescence uneventful. Two weeks after operation could abduct left upper easily fifteen degrees more than the right.

Second operation: July 24, 1924. Same procedure as above, except much freer marginal resection, and osteotomy at base of acromion, so permitting shoulders to be placed more posteriorly as well as inferiorly. (It is my feeling that the shortened acro-

mion accounts for this scapula lying flatter on the back, and for this shoulder having a better slope and giving the appearance of greater length to the neck.)

Convalescence: Rather stormy for four days but not dangerously ill. Figure-of-eight dressing maintained for four weeks.

The functional result at the end of eight months is more than 80 per cent. normal; the cosmetic result is very satisfactory to the boy and his parents.

This procedure for undescended scapula may well be called a subperiosteal transplantation to a lower plane in the muscular envelope of the scapula. The anatomic and physiologic relations of the muscles are maintained;

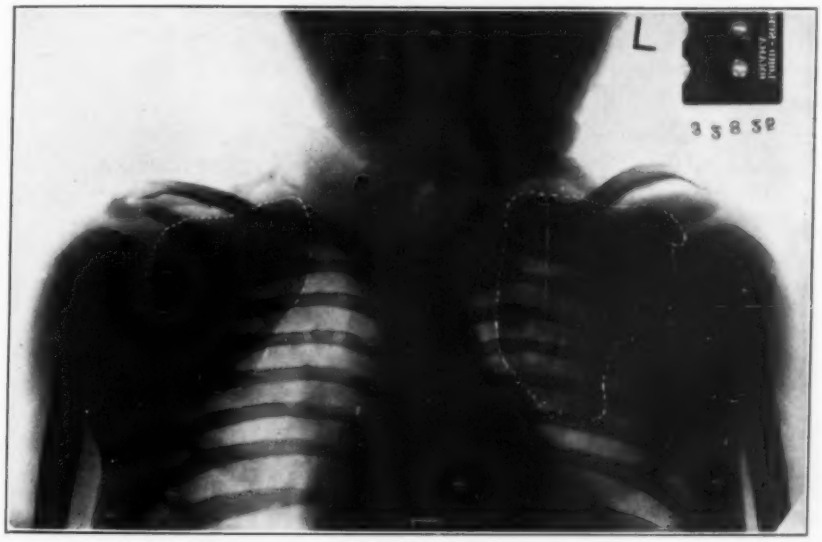

FIG. 11. CASE II

Left—Twenty months post-operative.
Right—Eighteen months post-operative

there is little probability of injury to important vessels or nerves, as the suprascapular nerve and artery are the only ones presenting. The greatest danger arises from the anchoring of the inferior angle about a rib; the haemo-pneumo-thorax should be of only short duration.

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APPARATUS FOR POST-OPERATIVE MANAGEMENT OF GUILLOTINE AMPUTATIONS OF THE THIGH

BY R. M. YERGASON, M.D., HARTFORD, CONNECTICUT

Orthopaedic Surgeon, St. Francis Hospital

The apparatus here offered for the management of guillotine amputations consists of two essential elements, a splint and a tractor.

The splint is made of one-quarter inch iron rod, and has a ring, covered with garden hose, identical with that of the ordinary Thomas splint. Four longitudinal rods equally distant from each other project from this ring and converge slightly to a point about six to eight inches below the end of the amputation stump, where their ends are welded to a second ring five inches in diameter. This cage-like apparatus constitutes the splint and is easily understood by reference to the photographs.

The tractor consists of a threaded bolt, six inches long, solidly attached at one (proximal) end to a round plate three and one-half inches in diameter, which is perforated near its margin by four equally distant and radially placed slots. These slots are one-quarter inch wide, their outer ends coming close to the margin of the plate, their inner ends being one inch from its center.

The next (second) member upon the bolt is a large washer, or small plate, one and one-half inches in diameter. The hole in it is large enough to allow it to slide freely upon the bolt. Four hooks, of three-sixteenths inch rod, three and one-half inches long, are attached to the margin of this plate by hinge joints. These hooks pass through and slide freely within the four slots in the larger plate and serve for the attachment of the four adhesive plaster traction stickers.

The third member upon the bolt is a wing-nut, bearing against the small plate, thus controlling the degree of divergence of the hooks.

The fourth member upon the bolt is a transverse bar of five-eighths by one-eighth inch strap iron, the ends of which are hooked over opposite sides of the distal ring of the splint, thus serving to hold the tractor in position. The threaded bolt passes loosely through a hole in the middle of this supporting bar.

Next upon the bolt there is a light compression spring, two and one-half inches long, to provide the pull, and on the end of the bolt a washer and wing-nut complete the assembly.

The tractor may seem unnecessarily complicated. To this I can only reply that it is light, effective, and convenient. Being able to adjust the divergence of the hooks to a point corresponding to the size of the rapidly shrinking amputation stump is a real point in its favor.

The subject of this paper being limited to the apparatus already described, the following illustrative case is not reported in full. Suffice it to say that the patient, James A., age 23, in perfect general health, had

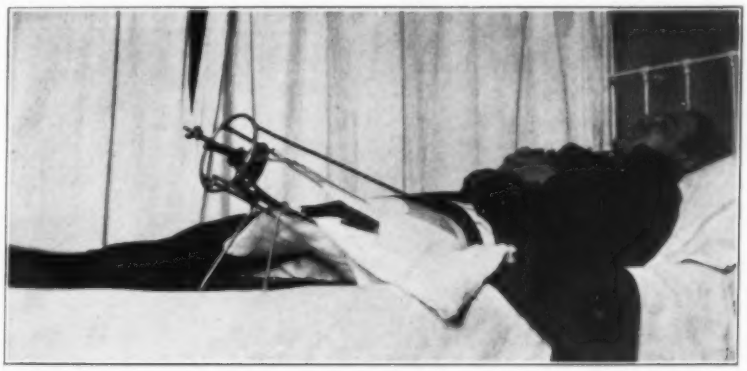

FIG. 1

General view of apparatus. Dressing open so that wound may be seen. A spanner supports the splint simply for better photographic view.

osteomyelitis of the lower third of the left femur with ununited fracture three inches above the knee joint, the result of operations and bone erosion. There was bony ankylosis of the knee and five discharging sinuses. He had been on crutches twenty-one months without improvement and, becoming tired of his condition, requested amputation.

A pseudo-guillotine amputation of the thigh was decided upon as the best means of conserving length of stump and eliminating infection.

On April 9, 1923, after routine pre-operative care and under ether anaesthesia, the operation was performed as follows:

The leg was held elevated for some time, an Esmarch bandage and tourniquet then being employed. A circular incision was made through the skin and deep fascia in such an oblique position that the posterior and

outer part was about one and one-half inches higher than the antero-internal portion. The hands of an assistant on either side of the thigh retracted the skin upward and, while this retraction continued, the muscles were cut through to the bone concentrically, a little at a time. All nerves were freed, drawn down and transected, and all vessels ligated as they were encountered. The bone was next sawed obliquely, corresponding to the skin incision. No retraction was necessary, other than that supplied by

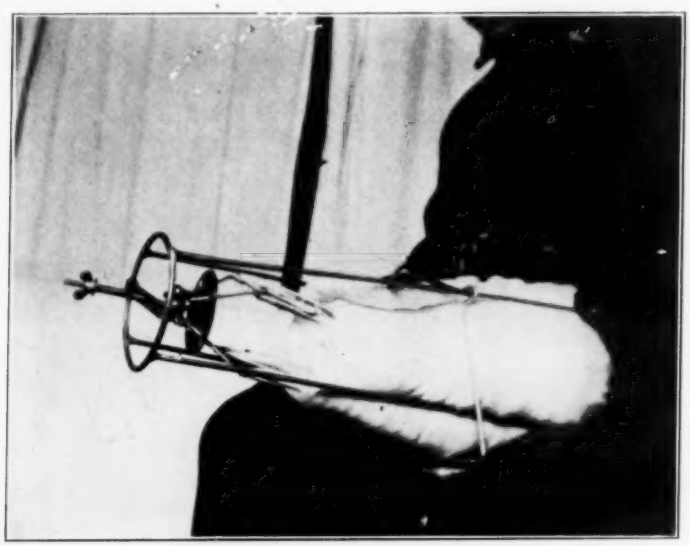

FIG. 2

Patient sitting in chair. Spanner being attached to the upper bar of the splint and resting on the seat of the chair below. The dressings are in place and a large support pad can be seen.

the hands of the assistant on the sides of the thigh. No periosteal or other type of flap was employed. The tourniquet was next relaxed, bleeding points ligated, and the edges of the bone were smoothed off.

The stump now presented a slightly oblique, flat surface,—bone, muscles, and skin all being the same length. No sutures whatever were used on the face of the stump, which presented the flat surface already described, with a small amount of oozing, principally from the bone. Dressings saturated with Dakin's solution were applied to the raw surface and held in place while four broad adhesive stickers were applied to the skin of the stump, extending from close to the edge of the wound as high

up as possible. A broad transverse strip of adhesive plaster passing about the thigh held them firmly.

The special splint and traction apparatus was immediately applied and the ends of the adhesive stickers made fast to the hooks of the tractor. (A pull of about ten pounds by the tractor, which equally divided itself between the four stickers, was found to be sufficient.) Within the ad-

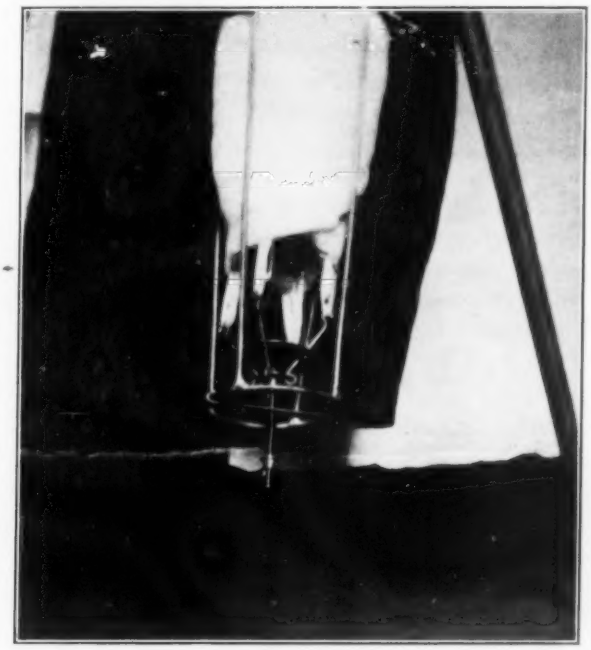

FIG. 3

Patient standing on crutches. His bathrobe is tucked behind apparatus to show its position.

hesive bands a gauze-enclosed cotton pad held the Dakin solution dressings in place without the necessity of a bandage or strapping, thus allowing free action of the traction bands.

The dressings saturated with Dakin's solution were changed once in twenty-four hours. No pus was ever seen after the operation. On the first day after operation the temperature was 100.6 and the pulse 100, which was the highest either ever attained. At the first dressing the bone was concealed by a thin clot which was not disturbed. On the second day

the cut ends of the muscle were covered with vigorous granulations. The end of the bone was never seen after operation, except on the first day when it was covered with a clot, as already noted. On the sixth post-operative day the patient used a wheel chair. On the ninth day he walked well on crutches, the splint and traction apparatus remaining in perfect position, without other support than that supplied by the four adhesive stickers furnishing the traction.

On the tenth post-operative day the whole apparatus was removed, the skin of the thigh shaved, new adhesive applied, and the traction re-established. The area of the wound was considerably reduced by this time, the entire area granulating, with epithelium advancing smoothly about the margin.

The photographs accompanying this report were all taken on the seventeenth day. On the twenty-first day the apparatus was discarded and the patient discharged from the hospital. At this time the circular wound was three inches in diameter. A small Balsam of Peru dressing was applied and the skin strapped over this from front to back. Massage, carried out largely by the patient with two felt mallets, was begun.

On May 25, forty-six days after the amputation, the patient was returned to the hospital and the next day the small scar (one and one-half inches in diameter) situated on the postero-inferior aspect of the stump was resected, and a transverse linear scar thus substituted for the circular one. The patient was discharged from the hospital the day after, which proved to be too soon, as three of the stitches cut out, due to swelling in the dependent position. Barring this small accident the ultimate healing was satisfactory, there being only slight puckering of the skin about the very small scar.

On July 7 the first artificial leg, a crutch with plaster-of-Paris socket, was applied. The patient now wears his permanent artificial leg.

SUMMARY

1. An original splint and traction apparatus for post-operative management of guillotine and pseudo-guillotine amputations of the thigh is here described.

2. The advantages of this apparatus are:

(*a*) It furnishes gentle, continuous traction on the soft parts of the thigh.

(*b*) The tractor is adjustable to suit the size of the stump as it shrinks.

(*c*) The four bars of the splint hold dressings in place and preserve proper alignment of the traction bands.

(*d*) It can be used for skin traction on any thigh amputation where there is a stump.

(*e*) When the patient takes to crutches it requires no support other than the traction stickers.

(*f*) It is comfortable to the patient.

(*g*) It is light.

3. In the presence of infection, the author prefers the pseudo-guillotine amputation and the use of this apparatus to any sort of flap operation.

4. A case history illustrative of the use of the apparatus shows the following advantages of the method:

(*a*) As there is no dead space, which often exists with flap amputations, no pus is ever seen after operation.

(*b*) The bone is immediately covered by muscles so that it is seen only for a day or two.

(*c*) The patient is ambulatory within a few days, which favors shrinkage of the stump.

(*d*) The scar is smaller than that resulting from flap amputations and its ultimate position can be controlled by proper selection of the plane of amputation.

5. The illustrations accompanying this article were all taken on the seventeenth post-operative day.

CLINICAL CONFERENCE AT THE HOSPITAL FOR THE RUPTURED AND CRIPPLED, NEW YORK, SEPTEMBER, 1925

THE PRESIDENT, DR. ARTHUR KRIDA, IN THE CHAIR

DR. R. WHITMAN—Giant Cell Sarcoma of the Tibia.

Dr. Whitman presented a man of 44 years of age whom he had first seen last April. Just below the knee joint on the outer aspect of the right tibia there was a tense, prominent swelling about the size of a half orange, which on X-ray examination was found to be an extension of a cystic tumor of the head of the tibia which had destroyed the cortex at this point. The patient was a street pedlar. He had suffered some discomfort for about two years, but had continued his work until seen. There was no interference with the joint motion.

At operation, April 24, 1925, the tumor and sac contents was a reddish grey, fairly firm mass of what appeared like granulation tissue. The enclosing bony wall was irregular and rough, evidently the effect of the destructive action of the tumor. The head of the fibula was involved, and in one place only bare cartilage separated the cavity from the joint. The wound was packed because of the bleeding, and afterward treated for a time with Dakin's solution. The opening slowly lessened in size. A brace was applied and he resumed his work early in September wearing the brace. The cavity still communicates with the exterior, but there is no deformity and there is a range of about 20 degrees of motion in the joint.

The duration of the symptoms, the destructive action of the tumor on the bone without involvement of the soft parts, and the effect of the operation would seem to indicate eventual recovery.

DR. P. W. ROBERTS—Unusual Case of Osteomyelitis of Tibia.

Dr. Roberts presents the case of a man 47 years of age who had an osteomyelitis of the left tibia thirty-five years ago. After operation and the use of crutches for three years, he remained apparently well until June, 1925. After a slight trauma, pain appeared in the left leg and all the symptoms of infection occurred. At another hospital the leg was opened, but the symptoms persisted. He was admitted to this hospital with a clinical picture of acute sepsis.

This case is reported to illustrate the danger which may lurk in an apparently cured osteomyelitis, and also to indicate the impotence of modern treatment in certain cases of septicaemia.

DR. WHITBECK—Bilateral Congenital Dislocation of Hips. Result Twelve Years After Reduction.

Dr. Whitbeck presented the case of a child who was operated upon at the age of 22 months for double congenital dislocation. The usual Lorenz reduction was employed and plasters applied to the limbs with the thighs in the frog position. The treatment was carried on for a period of about eight months and the result was satisfactory. At the end of twelve years the girl presented herself complaining of fatigue in standing and

walking, no pain. Examination: the patient was greatly overweight and presented a moderate degree of knock-knees and marked flat feet. Examination of both hips showed no limitation of motion in any direction. The hips were apparently in their normal position. Examination of the roentgenogram showed that the heads were somewhat out of the acetabula at the upper border. The neck of the femur on both sides was broadened and the head flattened. There were two spurs at the head of the left femur; none on the right side. The acetabula were fairly normal in appearance.

This case is interesting from the standpoint of the change from the normal which appears in the roentgenogram, simulating Perthes disease.

The child had no symptoms usually accompanying such disease that she can remember. Other cases of this nature have been reported and shown and it had been suggested that trauma upon the reduction of the hips may have been the cause.

Dr. S. Kleinberg—Maternal Birth Paralysis—Two Cases.

Dr. Kleinberg presented the case of Mrs. P. R., age 28. In June, 1924, this patient went into labor with a full term fetus. The labor was difficult and on account of an unusually large fetal head the labor was terminated by a craniotomy. On recovering from the anesthetic the patient immediately complained of severe pain in both lower limbs and was unable to move them. Within twenty-four hours she was able to move her thighs, but there was a distinct bilateral drop-foot. The pain was located on the outer side of the legs and on the dorsal aspect of both feet. Within a week the left drop-foot disappeared. The pain continued in both lower limbs, but the paralysis was limited to the anterior leg group on the right side. There were mild sensory disturbances in both legs, diminished galvanic and faradic response in the peroneal and anterior tibial groups on the right side, and some impairment of response in the posterior tibial group of both legs. December 10, 1924: there was pain in the right foot and leg and a persistent drop-foot. The anterior leg group, the peronei and the tibialis posticus were paralyzed. The long flexor muscle of the big toe was weak. September 23, 1925: she has had no pain in the right leg for many months. There was, however, numbness in the right leg and a persistent drop-foot. This patient originally had a bilateral sciatic nerve lesion due to pressure on the lumbo-sacral cords at the inlet of the pelvis from an unusually large fetal head.

Case 2. Mrs. R., 23 years old, went into labor June 22, 1925. As there was no progress at the end of thirty-six hours, a high forceps was resorted to and a dead child weighing 8½ pounds was delivered. The child's head was not abnormally large, but the maternal pelvis showed a bilateral symmetrical contraction. When the patient recovered from the anesthetic she complained that the left lower limb felt cold and numb, as if asleep. On the third day the left limb became very painful. The pain was located in the buttock and in the outer side of the leg and foot. Examination three weeks postpartum showed weakness of all the muscles of the left lower limb and a drop-foot. September 23, 1925: The pain was diminished. She walked with a left limp. There was marked improvement in all of the muscles of the left lower limb. She had good control of the muscles about the hip and knee. Below the knee the posterior leg and peronei muscles were active and fairly strong. The anterior leg group was active but weak. She was able to dorsi-flex the foot to 100 degrees. There was moderate atrophy of the thigh and leg. This patient had a lesion of the left sciatic nerve resulting from pressure on the left lumbo-sacral cord due to a normal fetal head passing through a contracted pelvis.

Dr. A. Krida—Flap Skin Graft for Keloid Scar of Heel.

Dr. Krida presented the case of a woman, 38 years of age, upon whom he had done a flap skin-graft operation three months previously for a troublesome keloid-like scar overlying the tendo Achillis region. The scar was two inches in length, adherent to the underlying tendon, presented coarse transverse fissures, and a "heaped up" appearance suggestive of keloid.

The condition was of six years' duration. At that time, while having radiograms taken of the teeth, the current was short-circuited, and she received X-ray burns of both heels. That on the right heel was mild, and healed up. On the left side suppuration ensued, and five drainage operations were done at various times. Subsequently three scar excision operations were done without relief.

At operation the scar was widely excised. The tendon was freed from rather extensive fibrous tissue. A flap of skin was turned up from the outer side of right leg, the left ankle approximated to it, and the three free edges of the flap were sutured to the defect by silkworm gut sutures. Plaster-of-Paris was applied to maintain approximation. The base of the graft was severed on the fourteenth day and stitched to the remaining edge of the defect with silkworm gut sutures.

The graft healed in by first intention. The skin over the tendon is rapidly becoming mobile. The functional result is satisfactory.

Dr. A. Krida—Unhealed Amputation Stump; Periarterial Sympathectomy; Flap Graft.

Dr. Krida presented a man, 27 years of age, who came under observation in June, 1925. There had been an amputation below the knee for traumatism three years previously. Reamputation had been done twice, but the stump had been useless for wearing a limb.

The stump presented a sluggish, painful ulcer one and one-half inches in diameter. Periarterial sympathectomy on the femoral artery was done in June. The ulcer healed in eight weeks. The stump now presented a considerable area covered with rather thin scar, intimately adherent to the underlying bone. On September 9, a flap graft operation was done. A circular scar two inches in diameter was excised, a flap was raised from the inner side of the other leg, and all but the base stitched to the margin of the defect in the stump end. Plaster-of-Paris maintained approximation. In seventeen days the base of the flap was severed. The transplant healed in by primary union.

Dr. K. Hansson—Volkmann's Ischaemic Paralysis—Two Cases.

Dr. Hansson presented two cases of Volkmann's ischemic contracture, illustrating extreme types; also treatment and prognosis.

Case 1. T. B. G., age 12. Sustained a fracture of left radius, distal end, on August 27, 1924. The treatment, which patient received in another hospital, consisted in application of P. P. splints. He came to this hospital on October 23, eight weeks later, and presented then a typical Volkmann's contracture. Left elbow was held in semiflexion, wrist in slight extension, and fingers in flexion. There were five pressure excoriations on the forearm, which was markedly atrophied. Hand was cold, swollen, and bluish, and no supination was possible. Roentgenograms taken on admission to the out-patient department showed a fracture of the left radius about one and one-half inches from the distal end, in fairly good position and with good callus. He was given a brace for correction of the wrist and hand, so applied that when the wrist was flexed the fingers were extended and easily held in that position. With fingers held in ex-

tension, the wrist was gradually extended. Patient was admitted to physiotherapy department on October 30. He was given: 1. Whirlpool bath, 15 min., 110 F.; 2. Diathermy through contractures 20′ and 800 mamp.; 3. Electrical stimulation of the overstretched muscles, first interrupted galvanic, later slow sinusoidal; 4. Medium massage of the whole upper extremity; 5. Passive exercises for stretching of contracted flexors and active exercises for extensors of forearm and hand. This patient was discharged on January 24, 1925, with complete recovery.

Case 2. D. D., age 11. Fell on her left elbow in 1920 and roentgenograms showed a supracondylar fracture extending into elbow joint. The fracture was reduced and put up with elbow in acute flexion by means of P. P. splintage. This was followed by pressure wounds about elbow and wrist, which became infected, and contractures of forearm and hand. In the fall of 1920 patient presented an ankylosed left elbow and atrophy and contractures of forearm and hand. At this time an arthroplasty was done without any treatment for the contractures. Since that time patient has had braces but no other treatment. Patient was admitted to physiotherapy department September 3, and has had only six treatments. She is also wearing a brace as described above. She presents an advanced type of Volkmann's contracture. Duration five years. Left elbow is ankylosed. The atrophy is marked and there is no motion of wrist or fingers. Patient is to try physiotherapy for three months in addition to the brace, and if there is no improvement an operation may be considered, although functioning forearm and hand can hardly be hoped for because of the marked connective tissue changes in the muscles.

News Notes

The orthopaedic surgeons of the Pacific Northwest organized a sectional society, on June 29, 1925, upon the occasion of the annual meeting of the Pacific Northwest Medical Society in Portland, Oregon. The new society is in a way the outgrowth of the Seattle Surgical Society.

Dr. Nathaniel Allison of Boston was the guest of honor and was made the god-father of the organization and its first honorary member. Seventeen members were present and formed the society. It was planned to meet in various Northwest cities once in the summer and again in the winter of each year.

The officers elected were:

Dr. Edward A. Rich, Tacoma, President.
Dr. Charles R. McClure, Portland, Vice-President.
Dr. Roger Anderson, Seattle, Secretary and Treasurer.

The membership consists of the following orthopaedic surgeons in addition to the officers above named: Drs. O. F. Akin, Portland; S. C. Baldwin, Salt Lake City; J. C. Brugman, Seattle; E. C. Carlson, Portland; Richard Dillehunt, Portland; C. F. Eikenbary, Spokane; R. L. Jeffrey, Seattle; Mitchell Langworthy, Spokane; M. C. Lile, Seattle; F. C. McTavish, Vancouver, B. C.; D. A. Murray, Seattle; L. N. Ossman, Salt Lake City; F. P. Patterson, Vancouver, B. C.; H. J. Wyckoff, Seattle.

The first clinical meeting was held in Tacoma, in December, one day being given up to dry and operative clinics and the second to a cruise up Sound on Dr. Rich's yacht, the "Argosy."

The Section in Orthopaedic Surgery of the New York Academy of Medicine held a meeting on Friday evening, October 16, 1925.

The programme was as follows:

Report of Cases.

(a) 1. Osteomyelitis of the tibia; end result.
2. Fracture of the surgical neck of the humerus; two cases.
3. Fracture of the shaft of the femur; two cases.

Sidney Cohn (*by invitation*).

From Bellevue Hospital:

(b) Plastic repair for contracture of hand.

Fenwick Beekman.

(c) 1. Plastic repair of fingers.
2. Brodie's abscess treated by drilling.
3. Loose body in knee; operation.
4. Remade hip joint.

Reginald H. Sayre.

(d) Fractures about elbow joint: a series of cases.

Irwin E. Siris.

(e) 1. Compound comminuted fracture through both elbow joints, resulting in perfect function.
2. Suppurative arthritis of knee treated by Willem's method.

Edward A. King.

Discussion.

A second meeting was held on Friday, November 20, 1925, with the following programme:

Presentation of Cases.

(*From the Post-Graduate Hospital*)

(a) Cases of Arthritis — Intramuscular Injections of Sodium Phenol Iodid.

William H. Irish.

(b) 1. Pott's Disease; paraplegia; operation.
2. Dislocation of cervical vertebra; reduction.
3. Epiphyseal separation, lower end of femur.
4. Epiphyseal separation of lower end of radius.

Elmer P. Weigel (*by invitation*).

(c) 1. Bilateral complete syndactylism.
2. Paralytic deformities of the foot.

Leo Mayer.

(d) Interesting errors in diagnosis:
1. Fracture of the wrist.
2. Supposed fracture of clavicle.
3. Supposed hip disease.

Charles Ogilvy.

(e) Operative results—Knee cases:
1. Arthroplasty for mobility.
2. Habitual dislocation of the patella.
3. New growths.
4. Joint mice.

Fred H. Albee.

(f) Muscle transplantation for infantile paralysis demonstrated by moving pictures.

David R. Telson (*by invitation*).

Discussion.

At the meeting on the evening of December 18, the programme was as follows:

Presentation of Cases, Case Reports, and New Instruments.

(a) Staphylococcemia: multiple bone abscesses.

Abraham Urevitz (*by invitation*).

(b) 1. Osteosarcoma of skull: metastases in radius.
2. Hemorrhagic osteomyelitis of hip: thrombopenia.
3. Multiple epiphysitis.

Benjamin Koven (*by invitation*).

(c) 1. Osteochondritis of heel.
2. Femoral bone abscess.
3. A new metatarsal plate.

Morris T. Koven (*by invitation*).

(d) (*From Newark Beth Israel Hospital*)
Fracture of the body of lumbar vertebra, due to indirect violence.
Henry H. Kessler (*by invitation*).

(e) (*From Newark City Dispensary*)
1. Lymphangioma: congenital hypertrophy.
2. Congenital absence of fibula.
3. Osteoarthritis of the acetabulum.
4. Achondroplasia.
Carl R. Keppler.

(f) (*From St. Giles Orthopaedic Hospital, Brooklyn*)
Report of cases.
Charles Dwight Napier.

(g) Stabilizing operation for congenital hip dislocation in an adult.
Walter Truslow.

(h) (*From Long Island College Hospital*)
1. Two cases of claw feet—operative treatment.
Joseph B. L'Episcopo (*by invitation*).
2. Bow legs due to congenitally long fibulae: operation.
Jacques C. Rushmore (*by invitation*).
3. Transplantation of great trochanter for coxa vara.
Herbert C. Fett (*by invitation*).

PAPER OF THE EVENING.
Synovectomy in infectious arthritis; lantern slides.
Paul Swett, Hartford, Conn. (*by invitation*).

DISCUSSION.

The Commission of the Istituto Ortopedico Rizzoli, of Bologna, has awarded the prize for the year 1924 to Dr. Aladâr Farkas of Budapest for his work entitled, "Causes and Pathogenesis of Scoliosis."

The Commission was composed of Prof. Riccardo Dalla Vedova, Prof. Vittorio Putti, and Prof. Francesco Delitala.

The British Orthopaedic Association offers a Prize of £50 and a Medal to be given by Sir Robert Jones for an Annual Competition amongst members of the Association of all grades for an Essay on a subject in orthopaedic surgery.

The Essay is to be submitted typewritten, together with any illustrations and specimens, and forwarded to the Secretary on or before December 31st in each year. It must not bear the name of the writer, but should be identified by a motto and accompanied by a sealed envelope bearing the motto on the outside and containing the name and address of the writer inside. Only the envelope of the successful candidate will be opened. Unsuccessful Essays will be returned to the candidates on personal application.

The subject for the Essay for 1925 is:—"The Classification and Differential Diagnosis of the Different Forms of Arthritis." Essays to be submitted by December 31st, 1925.

The subject for the Essay for 1926 is:—"Affections of the Epiphysis and Epiphyseal Regions of the Bones, with special reference to their late effects." Essays to be submitted by December 31st, 1926. Address

R. C. ELMSLIE,
Hon. Secretary.

1a, PORTLAND PLACE, W.1.

At the First International Congress of Radiology, held in London, in July, 1925, Mr. C. Thurstan Holland was elected President, and Mr. Stanley Melville, Secretary.

It was voted that the next Congress be held in Stockholm in 1928, under the Presidency of Professor Gosta Forssell.

The regular meeting of the Chicago Orthopaedic Club was held on Friday evening, December 11, 1925, and was largely attended by many industrial and railroad surgeons as well as general and orthopaedic surgeons.

The programme was as follows:

(1) Modification of the Turnbuckle Jacket for the Treatment of Scoliosis.
Charles N. Pease, M.D.

(2) Treatment of Fractures of the Elbow in Children.
Marcus H. Hobart, M.D.

(3) Transplantation of Fibrous Tissue in Repair of Anatomical Defects.
William Edward Gallie, M.D., Toronto.

Discussion opened by Dr. Allen B. Kanavel, M.D.

On January 8, Dr. J. C. Bloodgood of Baltimore will address the Club on "A Brief Review of the Salient Points in the Diagnosis and Treatment of Benign and Malignant Lesions of Bone from an Industrial Standpoint."

Dr. Edwin W. Ryerson is the President and Dr. H. B. Thomas is the Secretary of the Club for the present year.

BOOK REVIEWS

DISEASES AND DEFORMITIES OF THE FOOT. John Joseph Nutt, B.L., M.D., F.A.C.S. Second Edition Completely Revised. New York: E. B. Treat & Company, 1925.

This book contains two hundred and ninety pages and is well arranged. The first two chapters are devoted to a brief anatomic and physiologic study of the foot, and, although some of the descriptions are a little hard to interpret, the author has made the subject remarkably clear in the small space allowed. A short chapter on routine examinations follows and contains very good suggestions.

The rest of the book is given to special foot conditions, their diagnosis and treatment. It contains much of value and offers help to those who are looking for definite directions in dealing with the great variety of the affections of the feet which demand attention. Perhaps too little stress is laid upon the etiologic factors, and the treatment is at times a little dogmatic, with too little variety to meet the varying conditions. On the other hand, simplicity may avoid confusion to those who are in search of a specific course of treatment which they may choose to follow.

Dr. Nutt is to be congratulated on producing a work which should be an aid to the medical practitioner.

A TEXTBOOK OF OPERATIVE ORTHOPAEDICS. A. Steindler, M.D., F.A.C.S., Professor of Orthopaedic Surgery, State University of Iowa. New York, London: D. Appleton & Company, 1925.

Professor Steindler brings to the task he set himself a large surgical experience with orthopaedic lesions, and his approach to the subject must appeal to all who have seriously thought upon such matters. From the days when orthopaedic surgeons were humorously styled "harness makers" to the present has indeed been a far cry and this is the first serious attempt to set forth the accomplishments of those who have applied operative therapy to the "harness maker's" problems. It is well to remember that the author looks upon operative procedure as only one of the therapeutic techniques of which the orthopaedic surgeon should be master, and has compiled the material herein contained because he believes the time has come to review the field and give the indications for the employment of one method rather than another. In arriving at his goal he has discussed the various problems with which he deals from their physiologic, biologic, and mechanical standpoints. The text is well supplied with references to the work already done, establishing the basis for building up the various techniques described. In the chapters on tendon treatment for contractures of all sorts the reasons for the greater popularity of open methods are well set forth and the applicability of tenotomy, tendon plasty, stripping operations (as in claw feet and flexure at the hip) are clearly given. Finney's work on spasmodic torticollis was the only omission noted in this part of the subject. In the section on tendon transplantation is much material valuable to any one dealing with tendon surgery. The old mechanical concept, solely governing operations of tendon transplantation, has given way to the physiologic concept, with great advantage to the patient as well as credit to surgical technique. Preservation of gliding function, selection of muscles for transference with respect to comparative strengths,

physiologic and anatomic antagonisms, methods of anchorage, mechanical advantage, utilization of entire tendon for transfer and imperative need for precedent correction of deformity,—all emphasize the grasp the modern operator must have of the subject before he ventures into the field of tendon transference. The particular applications are too numerous to be gone over. The modern use of fascia in the manufacture of tendons and plastic capsular reconstructions is well discussed, as are also the various procedures applicable to habitual dislocations at the shoulder, the patella, etc.

Of equal importance with the discussion of the biologic basis of tendon transplantation is the author's discussion of the processes of callus formation, bone transformation, and the influence of constitutional states upon these and the bearing that such considerations have upon all bone surgery.

There follows an enumeration in more or less detail of various operations for the correction of faulty alignment in the foot, at the ankle, hip, etc. The static principles underlying a determination upon any of these procedures are discussed and some space is devoted to consideration of equalizing operations upon bone—both shortening and lengthening. No reference was found to the possibilities of epiphyseal irritation as a means of stimulating osseous growth in the young.

The next subject to receive consideration is the repair of defects in bone and faulty processes of osseous union. Delay in solidification of callus and true pseudarthrosis are to be sharply differentiated. The history of bone grafting, from its earliest employment in 1858 by Ollier down to the present time, is succinctly given, together with a brief résumé of what is known or thought about the behaviour of grafts and the processes of bone regeneration and absorption. The special application of the principles enunciated to the fusion of vertebrae and for the treatment of various lesions in other parts of the bony skeleton receives careful consideration. Arthrodesis of the sacro-iliac joints, laminectomy, and costo-transversectomy are given due consideration.

The larger portion of the last half of the volume is devoted to the surgery of joints, in the discussion of which the author enters into the objects of joint surgery in general, apart from specific pathology, and proceeds to describe the best methods of approach to the various joints in accordance with which one of these different objects is uppermost in importance. Aside from inflammatory disturbances calling for the treatment of effusions, septic or otherwise, very much of the surgery of joints involves the question of stabilizing operations of one sort or another, which leads to a full discussion by the author of the various methods of arthrodesis and arthroplasty. The insertion of statistical tables to show the results reported by surgeons making extended reviews of the literature or from their own personal experience has added much to the value of the different methods of technique employed. It is in this subject of arthroplasty, where it is particularly important that evidence should be submitted which will be convincing to those who feel that a knee or a hip joint, ankylosed in a good position for function, is not likely to be exceeded in serviceability by *any* arthroplasty, that such statistics are interesting and may perhaps some day be conclusive to those who as yet are somewhat skeptical of anything but a very restricted application of the method in these particular joints.

A chapter is given to discussion of resection for osseous tuberculosis, in which attention is called to the fact that early operation is gaining advocates because of difficulties in diagnosis as well as because statistics show that many cases, seemingly cured, are only arrested. It may be, as the author has stated, that the questions raised by the advocacy of early operation on surgical tuberculosis need not be argued in a text book

of this kind, but it might well be within the province of one discussing operative methods from biologic and physiologic as well as mechanical and clinical standpoints, to condemn the application of arthrodesis in tuberculous joints in childhood.

The various bursae are enumerated and brief discussion of the methods of dealing with them in case necessity demands it are outlined.

The surgical procedures designed to provide motive power for prostheses in the treatment of amputations are fully described.

The final chapters are devoted to surgery of the peripheral nerves in the treatment of neuromas, nerve sutures of fresh injuries, and more particularly the procedures employed for the relief of the extreme spasticity of cerebral palsy or the injuries to the brachial flexus occurring in obstetrical paralysis.

Skin plastics and the after treatment of operative orthopaedic cases have a short chapter devoted to them.

The field has been well covered, and no one attempting to do orthopaedic surgery should fail to read the portions of this book which deal with the general principles governing the operative procedures advocated. However important and valuable the descriptions of the various techniques may be, and they are all valuable, the discussion of the indications for their employment is of infinitely more significance.

TEXTBOOK OF ORTHOPEDIC SURGERY. James Warren Sever, M.D. New York: The Macmillan Company, 1925.

The "Textbook of Orthopedic Surgery" is a presentation of the subject to the student as a simple and easily digestible pabulum. There are no masses of statistics, no conflicting and sometimes unproven theories to interpret. The author's valuations of the standard forms of treatment and the methods he advocates for the conditions under question are presented amply enough for the general practitioner as well as the student. The chapter on obstetrical paralysis is naturally very detailed. On the whole, the fundamental principles of orthopaedic surgery are enunciated and stressed as adequately as one would expect of an author who is conservative, temperate, and a well-balanced thinker on orthopaedic subjects.

Current Literature

FRACTURES AND DISLOCATIONS

TREATMENT (RUSSELL) OF FRACTURES OF FEMUR. E. D. Fenner. *New Orleans Med. and Surg. Journ.*, June, 1925, p. 520.

The author has given a very good description of the method of R. Hamilton Russell of Melbourne, Australia, but without the author's drawings it is much harder to see just how his pulleys are arranged. It is a system of traction with pulleys which are very comfortable and the patients are easily handled while wearing them. Twelve cases are reported in which this method was used, giving excellent results.—*Edward Sparhawk Hatch, M.D., New Orleans, La.*

THE TREATMENT OF FRACTURES WITH SPECIAL REFERENCE TO ITS ORGANIZATION AND TEACHING. George E. Gask. *Brit. Med. Jour.*, August 22, 1925, p. 317.

In a discussion of the above subject at a joint meeting of the Surgical and Orthopaedic Sections of the British Medical Association, Mr. Gask presented the viewpoint of the general surgeon. He admits that something is lacking in the present methods of teaching and treating fractures. He takes issue with Sir Robert Jones on the subject of segregating fractures and putting them under the care of specialists. He objects to putting undergraduate students under the care of specialists, but thinks students should be well taught in the fundamentals and leave specialism for post graduate work. He says the curriculum is already overloaded. The shortage of beds in hospitals is given as one reason for fractures not receiving better attention. He admits that certain reforms in teaching and organization are needed, and says there is evidence that attention is being paid to them. He does not say just what these "reforms" are, or what is being done.—*F. G. Hodgson, M.D., Atlanta, Ga.*

A NOVEL METHOD OF REDUCING A DISLOCATION OF THE ELBOW. A. S. Gubb. *Brit. Med. Jour.*, July 11, 1925, p. 60.

"The patient had a typical dislocation of the right elbow, the forearm being displaced forward." (?) Standing on the right side of the patient, Prof. Curtillet grasped the elbow with both hands, leaving the forearm free. Having raised the limb to an obtuse angle with the trunk, he then suddenly, taking the patient by surprise, imparted to the limb a violent flail-like movement, whereupon the displaced forearm slipped back into its place. There was considerable momentary pain. He said he had employed this method many times with invariable success.—*F. G. Hodgson, M.D., Atlanta.*

THE TREATMENT OF FRACTURES: ITS ORGANIZATION AND TEACHING. THE ORTHOPAEDIC STANDPOINT. Sir Robert Jones. *Brit. Med. Journ.*, August 22, 1925, p. 319.

The above subject was discussed at a joint meeting of the Sections of Surgery and Orthopaedics of the British Medical Association. The general surgeon's viewpoint was first given by George E. Gask, then followed by the paper by Sir Robert Jones. He said that the organization and teaching of fractures left much to be desired. The neglect of this important branch of work is mainly due to the rapid advances made in abdominal surgery. The operation soon over, the surgeon's care and responsibility end with the healing of the wound. The setting of fractures requires equal knowledge and skill, but this has to be continued without relaxation for weeks and often for months. Since the advent of X-rays, and consequently a critical public opinion, the surgeon's anxiety and responsibility are considerably increased. The patient expects functional perfection, and unless he obtains it the surgeon is in for trouble, whether he deserves it or not. A fracture is, therefore, not heralded as a kindly gift by the average surgeon. It is generally admitted by practically all those who have considered the matter that both the treatment and the teaching of fractures is unsatisfactory. After reviewing some of these unsatisfactory features the following scheme was suggested:

1. The necessity for the segregation of in-patient fractures either into: (a) wards under control of special surgical unit, or (b) in special wards not allocated to one unit alone.

2. The creation of a special out-patient fracture clinic, to be included with the fracture wards as part of a general scheme. Out-patient fractures should not be dealt with as a separate entity: in other words, their control should be under the surgeon or surgeons in charge of the fracture wards.

3. A surgeon in charge of the fracture department should be a consultant, the director of a unit, and one in whose practice and teaching the treatment of fractures will be maintained during the whole of his active surgical career. If there exists an orthopaedic department, as should be the case in every teaching hospital, the chief of this department should be one of the surgeons in charge of fractures, even if he is not the only one.

Then an outline of a fracture team is given:

1, one or more surgeons; 2, a senior assistant; 3, a physiotherapist; 4, a sister (or nurse) specially trained in fractures to have charge of the fracture ward. He then goes on to explain the advantages of this scheme, both to the patient and to the students.

A general discussion followed, participated in by S. W. Daw (Leeds), Robert Osgood (Boston, U. S. A.), H. Wade (Edinborough), Harry Platt (Manchester), H. H. Sampson (Birmingham), H. A. T. Fairbank (London), Prof. A. W. Sheen (Cardiff), C. Max Page (London), McAdam Eccles (London), Gwynne Williams (London), Prof. Andrew Fullerton (Belfast), R. C. Elmslie (London), Prof. A. T. Bazin (Montreal), W. R. Bristow (London).—*F. G. Hodgson, M.D., Atlanta, Ga.*

ACTION OF PERIVASCULAR SYMPATHECTOMY IN THE EVOLUTION OF FRACTURES. Mario Mairano. *Archivio di Ortopedia*, Vol. XLI, 1925, p. 36.

Kappis, in 1923, in a case of fracture of the femur with delayed union, performed a sympathectomy of the femoral artery and obtained complete cure in six weeks; Heymann in 1924 successfully treated an osteoporosis of the foot; Scalone reports solid callus in a fracture of the humerus with osteogenesis imperfecta. Mairano, in order to see how

this method acts in the evolution and acceleration of the callus, undertook an experimental research in dogs.

In conclusion he states:

1. The reaction and proliferative process in the vicinity of the periosteum and endosteum begins early and is very active.

2. The blood supplies of cartilaginous callus appear earlier and are numerous.

3. Ossification of the fibrocartilaginous tissue starts and ends hastily.

4. The absorption and rarefication of the new bone begins very early.—*Felipe Muro, M.D., Farmington, Mich.*

Separation of The Acromioclavicular Joint. By Barclay W. Moffat. *Surgery, Gynecology and Obstetrics,* July, 1925, p. 73.

Dr. Moffat does not believe in the efficacy of adhesive strapping nor does he deem it advisable that the joint in such a condition should be stiffened. He recommends open operation and stitches the joint in apposition by means of subperiosteal chromic catgut, after which a plaster spica with the arm at ninety degrees abduction is applied. Spica is removed in three weeks.

A report of eight cases is given and the author's conclusions are here quoted.

"*Conclusions.* 1. Strapping is mechanically inadequate to restore function of joint in all cases. 2. The operation of choice is curettage and suture of the two bones resulting in fibrous ankylosis. 3. The use of internal fixation leading to bony ankylosis of this joint is undesirable."—*H. A. Pingree, M.D., Portland, Maine.*

ARTHRITIS

Arthritis Deformans. Observations on its Etiology and Treatment. L. S. Ashcraft, L. Cunningham, T. P. McMurray, and H. S. Pemberton. *British Med. Jour.,* July 4, 1925, p. 13.

All forms of non-specific, hypertrophic or atrophic, active or inactive, arthritis are included. The investigation has been conducted from several sides:

1. *Clinical:* Daily observations made in the wards for as long as six months in some cases.

2. *Bacteriological:* The joints have been opened in a large proportion of the cases and from them an organism has been recovered which is identical in every case in its cultural and bio-chemical features. This organism does not correspond to any organism which has been previously described in so far as they have examined the literature. In only one case has it been discovered in the synovial fluid; in all other cases it has been isolated from either the membranes or the articular bone. No lesions have as yet been produced in animals. So far only the intravenous inoculation of rabbits has been attempted. Nothing constant has been isolated from foci of sepsis, feces, urine, blood, or fasting stomach contents.

3. *Metabolic:* Routine examinations have been made of gastric secretions, basal metabolism, acid-base ratio, renal and hepatic efficiency, and of glucose tolerance. The outstanding features so far appear to be: the large proportion showing achlorhydria or hyperchlorhydria, the practically universal diminution of carbohydrate tolerance, and the relative absence of acidosis, renal or liver defects, or any change in metabolic rate.

4. *Therapeutic:* Apart from correction of deformity and removal of focal sepsis wherever practicable, the only routine treatment employed has consisted in the use of 0.4 per cent. hydrochloric acid and a carbo-hydrate free diet extending over a period of months. Improvement, first by diminution of pain and then by increased mobility, has been obtained in practically every case, even without removal of focal sepsis.—*F. G. Hodgson, M.D., Atlanta.*

PROTEIN SHOCK IN THE TREATMENT OF RHEUMATOID ARTHRITIS. J. N. Cruickshank. *The Medical Journal and Record*, May 20, 1925.

Protein shock is an attempt to increase the non-specific defensive mechanism of the body by the injection of foreign proteins. The true nature of the reaction is not known. Rheumatoid arthritis is one of the diseases which seems at times to have been benefited by this method of treatment.

Clinically, the reaction has the following features: A definite chill, followed by rise in temperature, pulse rate, blood pressure, and leucocytes, and by profuse sweating. Headache, nausea and vomiting, and nervous excitement may be present; sometimes enlarged spleen and albuminuria. It has been demonstrated that the blood enzymes are increased after protein shock. The author has used typhoid vaccine, intravenously, and peptone intramuscularly in his investigation; the vaccine, in doses of one hundred million to begin with, later one hundred fifty to two hundred million, the intervals between doses being five to seven days, and total number of doses depending on the degree of improvement which follows in the joints. There may be considerable local reaction in the joints following the injection.

Peptone was used intramuscularly, in dosage of .3 to .6 grams, dosage increasing until productive of a temperature of 101, the number of injections and the interval depending on the effect on the joints; usually four or five injections at intervals of about one week.

Protein shock is not claimed to be a cure for arthritis deformans, but in a certain proportion of cases is followed by definite clinical improvement. It is to be considered an adjuvant to other therapeutic measures. It can have no effect on old standing lesions with structural changes. It is still in the experimental stage.—*Edward N. Reed, M.D., Los Angeles.*

CLINICAL STUDY OF RHEUMATOID ARTHRITIS. A. H. Douthwaite. *Brit. Med. Jour.*, June 27, 1925, p. 1170.

Observations based upon examination of fifty patients, thirty-eight of whom were females. Gradual deterioration of health preceded the pain in every case. In 20% of cases an illness probably precipitated the onset of the disease. In no case was more than one joint involved in the original attack. The small joints of the spine are often involved early in the disease. Skin is usually moist, often discolored or pigmented. *Cardio-vascular system:* The blood pressure was invariably low. There was marked daily variation in the pulse rate, but rapid pulse was not constant. No definite blood picture was obtained. Leucopenia and increase in lymphocytes was observed. Muscular weakness and wasting appeared constantly. *Gastro intestinal:* Achlorhydria or marked hypo-chlorhydria was not observed. Gastroptosis and enteroptosis were frequently observed by radiograph. Dental and tonsillar infection was the most frequent focus of infection.

Treatment: (1) Immobilization of joints (extension splints); (2) Eradication of septic foci; (3) Autogenous vaccines; (4) Massage and passive movements; (5) Auto serotherapy; (6) Fresh air and sunlight baths.—*F. G. Hodgson, M.D., Atlanta.*

The Treatment of Chronic Arthritis. Leonard W. Ely. *California and Western Medicine*, September, 1925, p. 1157.

Believing that arthritis is caused only by trauma or by infection, Ely divides the arthrites primarily into traumatic and infectious.

The treatment of traumatic arthritis is standardized. Infectious arthritis he subdivides into two great groups which he calls Type 1 and Type 2. Type 1 is characterized pathologically by proliferative inflammation in the bone marrow, or the synovial membrane, or both, and roentgenologically by the absence of lipping or spurring. Type 1 includes tuberculous, syphilitic and typhoid arthritis, coccidioidal granulomata, and the arthritis presumably caused by the diplostreptococcus from the tonsil or deep urethra; also the arthritis due to so-called focal infection. Tuberculous arthritis is strictly confined to synovial membrane and bone marrow. When function in a joint is prevented, lymphoid marrow and synovial membrane tend to disappear, and with their disappearance the disease dies out. The treatment of tuberculous arthritis includes prevention of function in the joint, avoidance of secondary infection, and building up resistance. The same treatment applies to the coccidioidal granuloma. The treatment of luetic arthritis is the treatment of the underlying disease. Typhoid arthritis is treated on general principles.

The other varieties of Type 1 are caused by bacteria domiciled most frequently in the tonsils or deep urethra: and these are cured by the removal of the focus of infection.

Type 2 is characterized by the presence of bony or cartilaginous outgrowths in the region of the attachments of the capsule. It is the so-called hypertrophic arthritis or osteo-arthritis or arthritis deformans.

The prime pathologic feature is an aseptic necrosis in the bone. The author believes the causative agents to be intestinal protozoa, although admitting that he has no reliable proof of their presence in the bones.

Examination of the stools of patients suffering from this form of arthritis has demonstrated parasites in 30%: most frequently the amoeba coli; at times giardia, chilomastix, histolitica, or trichomona.

Most of these cases present diseased bone at the roots of dead teeth, through which the author believes the parasites gain access to the blood stream and thence to the bone.

Treatment of these cases includes the removal of dead teeth, search for intestinal parasites, and parasiticide treatment, with neo-arsphenamim, emetin, and ipecac.—*Edward N. Reed, M.D., Ocean Park, Calif.*

Compression of the Spinal Cord and its Roots by Hypertrophic Osteoarthritis. By Harry L. Parker and Alfred W. Adson. *Surgery, Gynecology and Obstetrics*, July, 1925, p. 547.

A report of eight cases in detail is given. These all showed definite interference with nerve function, both motor and sensory. The symptoms were stopped or relieved by laminectomy at the levels indicated. Bony hypertrophy was found to be reducing the lumen of the spinal canal, and to be impinging upon the cord or nerve-roots. The

roentgenogram was of little use as a positive diagnostic help because the bony lesions were on the inside of the spinal canal. Obstruction of the canal was determined by lumbar puncture resulting in yellow fluid, and the level was indicated by the distribution of nervous symptoms. These cases all obtained relief from pain by lying down, which indicated that posture in recumbency had a marked effect upon mechanical pressure on the cord and nerve-roots, a marked contrast to the spontaneous lighting up of pain due to the pressure of cord tumors, in which case active exercise generally brings relief. An excellent paper, well arranged and clearly set forth.—*H. A. Pingree, M.D., Portland, Maine.*

Roentgen Treatment of Chronic Spondylitis Deformans. (Chronic Sacroiliac Lumbalgia or Chronic Vertebral Rheumatism.) Charles A. Pfender. *American Journal of Roentgenology and Radium Therapy*, June, 1925, p. 551.

In this disease the most marked changes, as seen in the roentgenograms, are found at the sides of the spinal column and consist in the formation of hooks or "parrot beaks," thought to be due to calcium deposits in the lateral ligaments. The process begins in the lumbar spine and slowly progresses upward, resulting finally in ankylosis with varying degree of kyphosis. The process is accompanied by periods of paroxysmal pain, lasting several months and recurring frequently, accompanied by pains in the legs and joints.

Attention is called to the narrowness of the bony canals through which the spinal nerves, especially the lower lumbar, must pass. The attendant pain the authors believe to be due to pressure on the nerve by the inflammation of the soft structures lining the foramina through which it passes. This conclusion they reached because X-ray treatment relieves the pain in selected cases, but has no effect on osseous lesions. "When an inflammatory focus exists and the radio sensitive cells are destroyed by the roentgen ray, decompression takes place and the pain disappears."

Histories of five cases are related, in all of which the pain was relieved by X-ray treatments, three to six or more in number, the usual dosage being 5 ma., 5 to 10 min., 4-6 mm. Al, and 6 mm. leather, 12 in. distance and 9 in. gap.

Early cases are most amenable to X-ray treatment, and light doses are more successful than heavier ones.—*Edward N. Reed, M.D., Ocean Park, Calif.*

TUBERCULOSIS

Result of Albee Operation in a Case of Tuberculosis of the Spine. Salvatore Ciaccia. *Archivio di Ortopedia*, Vol. XLI, 1925, p. 124.

The author reports the clinical history of a girl eight years of age, affected with spinal caries, involving the first two lumbar vertebrae, a slight lateral dislocation between the bones being present.

To prevent further deviation the writer performed an osteosynthesis following the Albee technique. One year later in the re-examination, the patient was found in excellent condition, but twelve months after she started to feel pain in the lumbar region, and a marked kyphosis was noticed. The radiogram showed that both vertebrae were destroyed and the spine at this point was totally displaced. From this experience Ciaccia believes that the opinion of Putti, Galeazzi, Ludloff, and others, against the

Albee method ought to prevail in the treatment of Pott's disease in children.—*Felipe Muro, M.D., Farmington, Mich.*

THE TREATMENT OF OPEN JOINT TUBERCULOSIS BY MEANS OF PLASTER CASTS. Egisto Capecci. *Zeitsch. f. orthop. Chir.*, Vol. 46, 4, 1925, pp. 525-532.

A method advocated and practiced by Solieri is reported and two typical cases are described. Solieri proceeds as follows: The periarticular abscesses are located, the fistulae cleared out and disinfected. A closed plaster cast is then applied which completely encases the diseased joint and the fistulae. The cast reaches to both neighboring joints. The cast is changed in about one month, earlier, if it has become too soft or if it does not fit any longer on account of having become too large because the edema of the joint has disappeared. Solieri and the author have had the very best results with this method. Healing was more rapid than by any other method of treatment of discharging tuberculous wounds. The favorable results obtained by this method cannot be ascribed to immobilization and to infrequent change of casts only, but to prevention of infection from without and to the autoserotherapy or autovaccination which results from the close and prolonged contact of the macerated skin about the fistula with the tuberculous pus. The odor which may develop and the softening of the cast from the pus which flows down from the fistulae may partly be prevented by exposing the casted extremity to the sun.—*A. Gottlieb, M.D., Los Angeles.*

TREATMENT OF WHITE TUMOR OF THE KNEE. L. Mencière. *Congrès français de Chir.*, October 7, 1925.

At a meeting of the French Congress of Surgery, held October 7, 1925, in which the subject of white swelling of the knee was discussed, Dr. Louis Mencière expressed the following opinions: "As resection accomplishes too much in the light cases and not enough in the serious cases, where a part of the lesion may escape the curette or the bistoury, Dr. Mencière has for many years been a partisan of the method of phenolisation. In this method it is necessary to distinguish two procedures, phenopuncture and the phenolisation itself. The first is applicable to cases of the first or second degree. It is limited to the destruction of osseous foci by the action of the phenol carried to the centre of the epiphysis, then neutralized by alcohol, following the technique. The second is intended, on the other hand, for serious cases in which resection would be indicated. The author considers that in these cases arthrotomy with synovectomy and very limited osseous intervention, but followed by long phenolisation, the action of which extends to a distance, produced complete cure with ankylosis in good position, without claudication and without shortening or with very slight shortening. This consideration is important, especially in young patients, for the method respects the articular cartilage. The only inconvenience is the necessity of closure by second intention, with very close watch during the period of elimination consecutive to the intense proteolysis which is produced after the phenolisation. In spite of the destruction of Dr. Mencière's records during the war, he has been able to collect ninety successful observations of patients between sixteen and forty-three years of age: twenty-eight of these with positive guinea-pig inoculation practised by Prof. Téchoueyres at the Laboratory of the Medical School.

NEOPLASMS

THE TREATMENT OF BONE SARCOMA BY TOXINS, RADIATIONS, AMPUTATION, OR RESECTION. By Joseph C. Bloodgood. *American Journal of Roentgenology and Radium Therapy*, September, 1925, p. 253.

Considering the efficacy of Coley's toxins, the opinion of the Registration Committee is cited, to the effect that in all of the years of recorded treatment "there is only one case in which cure may possibly be credited to the toxins alone."

Next is questioned, "Is there a larger percentage of five-year cures in the cases of sarcoma of bone in which, in addition to resection or amputation, the toxins have been employed?" There is no evidence that there is.

Failure to cure sarcoma is due not so much to local recurrence as to metastases in the lungs. The author can find no evidence that either toxins or radiations protect from metastasis: nor that pulmonary metastases can be cured by either. He has seen but one case, treated by radiation alone, in which a definite cure seems to have been accomplished: this in a periosteal sarcoma involving the upper part of the shaft of the humerus.

In any non-operative treatment, where no tissue is removed for study, there is a large element of error in the diagnosis of sarcoma of bone, and reports of cures under these conditions must be received with reservations.

A large number of verified sarcomas treated by amputation or resection have remained free from metastases after five years, and this method offers the only hope of cure. Radiation should be reserved for cases without hope of cure by amputation or resection.

All the author's cures in lower extremity sarcomas have been in those located below the middle third of the femur. "In the upper extremity there is not an authentic cure by amputation," and here resection, if possible, is the operation of choice.

The author feels that exploratory operation should be done only with preparations all made for immediate examination of the tissue, by frozen section, and for proceeding at once with whatever operation seems indicated. With lesions in the upper extremity or above the middle third of the femur, with resection and bone transplantation out of the question, radiation should be tried without exploratory incision.

While studying a case, this treatment is suggested: (1) Keep both limb and patient at rest. (2) Treat the local area with deep X-ray. (3) In periosteal lesions give intravenous salvarsan, in spite of a negative Wassermann. (4) Take roentgenograms, from different angles, of both the involved bone and the opposite uninvolved one: also of the chest and pelvis. (5) Laboratory tests, consisting of a provocative Wassermann, examination for Bence-Jones bodies in the urine, and repeated differential leucocyte counts.

Three case histories are given, to illustrate the difficulty of diagnosis at exploratory operation.

The author's rule is not to amputate in case of doubt as to malignancy: resection, with bone transplantation, may be done. He feels that it is wiser to send films before operation for confirmatory opinions from other surgeons rather than tissue from exploratory incision. Routine radiation of the lungs, in the post-operative treatment, has not prevented metastases in them.—*Edward N. Reed, M.D., Ocean Park, Calif.*

CASE OF KYPHO-SCOLIOSIS DUE TO A TUMOR. Silvio Crainz. *Archivio di Ortopedia*, Vol. XLI, No. 1, 1925, p. 3.

The greater number of tumors developed in the vertebral column are metastases derived from the breast, thyroid gland, uterus, and stomach. Primary new growths of the vertebrae are scarcely seen, so the case reported by Prof. Crainz is an interesting one. The patient was a girl, seventeen years of age, who for almost two years had been complaining of pain around the neck, with a swelling which gradually increased in size. When the author saw her, a kyphosis over the lower cervical spine with a scoliosis to the right was visible. The X-ray examination showed a mass involving the fifth, sixth, and seventh vertebrae. Upon operation the tumor was found to arise from the right lamina of the seventh cervical, and the pathologic diagnosis was an osteosarcoma. Crainz emphasizes that there are in the literature cases of different vertebral tumors, but none which has produced a scoliotic deformity. He believes that in his patient the scoliosis was produced by mechanical pressure similar to the scoliosis due to the presence of an hemi-vertebra.—*Felipe Muro, M.D., Farmington, Mich.*

OSSIFYING CHONDROMA OF A RIB MISTAKEN FOR A SARCOMA. Cecil P. G. Wakeley. *Brit. Jour. of Surg.*, July, 1925, p. 175.

Male, 42; was carrying a loaded ammunition drum under his arm when suddenly it exploded, causing severe pain in the right side of the chest; otherwise he was not hurt.

Soon afterward he developed a pain in the back of the shoulders which remained constant. Later he developed nephritis. This cleared up, but the pain in the back persisted. Seven years later he noticed a hard lump above and external to the right nipple. This was diagnosed as a malignant condition and radium was inserted into the tumor in three situations. The tumor increased in size and he became unable to write. A shoulder amputation was advised and declined.

Examination showed a large rounded tumor of the right chest wall. Pulsation was present in the upper part. There was slight weakness of the muscles supplied by the lowest brachial nerve-cord.

Operation was performed. The tumor was fixed to the middle of the fourth rib by a short pedicle about three-quarters inch in diameter. The tumor after excision measured seven inches by six inches. On section there were definite areas of ossification and in one place a mucoid degenerative area. The microscopic picture was that of a typical chrondroma.—*Alexander Gibson, F.R.C.S., Winnipeg.*

OPERATIVE PROCEDURES

TREATMENT OF MENISCUS LESIONS. E. Bressot. *Presse Médicale*, August 29, 1925, p. 1158.

Lesions of the meniscus are probably more frequent than is generally believed if all derangements old and recent are included. In addition to the complete rupture of the cartilage with locking of the knee, there are numerous cases of partial tears, either of the meniscus itself or its attachments, with hydrarthrosis.

Resection instead of repair of the cartilage is always done. Vertical incision is usually made, but the author has never been able to resect the posterior end of the

meniscus. The lateral ligament is cut, made to overlap slightly by bending the knee, and sutured, thus making it a little shorter.

Results of five cases have been observed four years, two years, nineteen months, nine months, and four months after operation. Three showed complete cure. Two still have a little pain and swelling. Removal of the cartilage does not seem to interfere with stability of the joint: in fact, two cases showed an appreciable decrease in lateral movement which had existed before operation. It has been suggested that both cartilages be removed to insure a firm level joint, but this does not seem necessary.—*William Arthur Clark, M.D., Pasadena, Calif.*

Post-Operative Treatment of Flexion at the Hip. A. Mackenzie Forbes. *Can. Med. Assoc. Jour.*, May, 1925, p. 730.

Two years ago a patient was operated upon for deformity of both hips after infectious arthritis. A subtrochanteric osteotomy was performed on one side. Following this, the lower fragment was pulled up so that it overlapped the upper fragment by about two inches. This experience recalled three things: first, the difficulty of maintaining the osteotomised ends when great correction is necessitated; second, the inadvisability of suddenly changing the alignment of the bones of an extremity which has been long deformed: third, the damage which might be done to vessel, nerve, and other tissue by sudden change.

For this reason it was decided that in future, patients for whom it should become necessary to perform a subtrochanteric osteotomy for deformity should be treated by traction and gradual reduction of the deformity as callus was thrown out which would act as a hinge to the fractured extremities and as the soft tissues readjusted themselves to the new conditions.

Six months ago a case occurred in which the application of this method was successfully carried out. A third case performed three weeks before the writing of the article also showed encouraging results.—*Alexander Gibson, F.R.C.S., Winnipeg.*

Etiologic Operation for Hallux Valgus. Hermann Matheis. *Ztschr. f. orthop. Chir.*, Bd. 46, H. 3, S. 419, 1925.

Theoretical considerations: If on account of insufficient muscle strength, weight-bearing produces a flatfoot, there results a disturbance of relation between the different parts of the foot. The heel and outer half of the fore-foot are thrown into pronation, while the inner half of the forefoot is supinated. (This theory has already been advanced by the author and has been substantiated by Wittek, Baisch, Brandt.) The big toe cannot follow this rotatory movement, supination, of the first metatarsal bone, being held in place by counterpressure of the ground. The supinatory rotation of the first metatarsal alters the functions of the abductor hallucis and abductor dig. V muscles. If the supination is well marked, the tendons of these muscles alter their position from the lateral to the plantar surface and their function changes accordingly. The abductor hallucis becomes a flexor-pronator and the abductor dig. V acts as a flexor-supinator. This altered muscle function and the position of the metatarsal head are the forerunners in the development of the splay foot and hallux valgus; they also explain the sequence of hallux valgus from the pes valgus.

Based upon these considerations, the author concludes that to correct the deformity it must be necessary to rerotate the first metatarsal bone and restore it to its previous

normal position. The "exostosis," which the author entirely denies and which is nothing more than the plantar part of the metatarsal head, will disappear, the big toe will resume its place parallel to the other toes and the depressed metatarsal arch will be lifted.

Operation: Incision along inner foot border from middle of last phalanx of first toe to the scaphoid bone posteriorly. Excision of bursal sac, opening of the joint between first metatarsal and cuneiform; the tendon of tibialis anticus is loosened from the metatarsal; the capsule split on the inner, plantar, and dorsal sides so that the metatarsal bone can easily be pronated.

The abductor hallucis is freed from its base, but the tendinous attachment is not severed. The metatarso-phalangeal joint is now opened by means of a horse-shoe incision with the convexity towards the periphery. Existing bone proliferations around the edges of the joint are bitten off by a Luer. The joint capsule is now split on the dorsal and flexor surfaces so that the toe can be placed in supination in relation to the metatarsal bone. The toe is now supinated and dorsally flexed. By means of dorsal pressure upon the metatarsal, it is brought in a position of plantar flexion. By this means the adduction and supination of the metatarsal is abolished and the "exostosis" has disappeared. The foot ought now to be in a normal shape. A few stitches are placed to close the metatarso-cuneiform joint in such a manner as to secure the pronated position of the metatarsal. The tendon of the tibialis anticus is now reattached in such a manner as to prevent its supinating function. The capsule of the big toe joint is closed, securing thereby the proper position of the big toe. The abductor hallucis muscle belly is attached by means of a few catgut sutures to the periosteum of the metatarsal bone. Skin closure and plaster splint, with the heel supinated and the forefoot pronated in order to correct the pes planus deformity. Postoperative treatment: Ten to fourteen days rest in bed in plaster cast, then adhesive strapping and attempt at weight-bearing. Four weeks later correct shoe and made-to-order arch support.—*A. Gottlieb, M.D., Los Angeles, Calif.*

Common Causes of Shoulder Pain. P. F. Butler and J. F. Elward. *The American Journal of Roentgenology and Radium Therapy*, June, 1925, p. 536.

The authors propose in this paper to summarize the causes of shoulder pain which are demonstrable by X-ray.

Those discussed are: 1. Hypertrophic changes of the cervical spine. These are usually limited to the bodies of the lower four vertebrae, those demonstrable by X-ray being on the anterior corners, around the intervertebral foramina. 2. Calcified cervical glands, adjacent to nerves. 3. Spurs on under surface of the clavicle, usually found near its outer end, congenital or following fracture, and pressing on branches of the brachial plexus. 4. So-called calcified subdeltoid or subcoracoid bursitis. This is more properly called opaque bursitis, since calcium is not always present, and the opacity may be cleared up by heat or electrotherapy. Distribution of the phrenic nerve is reviewed, and the paths for reference of pain in the shoulder, from lesions in the diaphragm, pleura, pericardium, liver, suprarenal gland, and stomach are traced.

The authors state that ten of the causes of shoulder pain may be shown on a single 10 x 12 film, so placed as to include the shoulder joint, lateral cervical region, supraclavicular region, upper portion of thorax on the suspected side, and superior mediastinum: viz., caries or erosion of cervical vertebrae, cervical ribs, cervical arthritis, calcified

cervical glands, spur on the clavicle, opaque subdeltoid bursa, aortic aneurysm, apical tuberculosis, apical neoplasm, mediastinal new growth, Hodgkins disease, and disease or injury of the shoulder joint itself.

Shoulder pain is a symptom of many conditions outside the shoulder region, the pain being through the phrenic nerve and brachial plexus, and in its X-ray investigation a 10 x 12 film should always be used.

The article is illustrated with reproductions of ten roentgenograms.—*Edward N. Reed, M.D., Ocean Park, California.*

MISCELLANEOUS

A Simple Splint for Baseball Finger. Philip Lewin. *Jour. A. M. A.*, October 3, 1925, p. 1059.

The splint is made of aluminum and is in one piece, running along the dorsal surface of the finger with three tabs on each side. These tabs practically encircle the finger and can be made tight or loose as occasion demands. It is apparently a very comfortable splint.—*Edward Sparhawk Hatch, M.D., New Orleans, La.*

An Analysis of Forty-One Cases of Thrombo-Angiitis Obliterans. By David Perla. *Surgery, Gynecology and Obstetrics*, July, 1925, p. 21

Dr. Perla has considered the clinical signs, symptoms, and treatment under separate headings. He shows that this is a chronic, slowly extending disease of the blood-vessels characterized by organizing thrombotic changes in the walls and lumen. As observed in a series of forty-one cases the victims were mostly men of an average age of 30 to 35, the duration of symptoms before gangrene was from one month to fourteen years and periods of remission from one month to fifteen years. Dr. Perla's conclusions are quoted below.

Summary and Conclusions: From an analysis of this series of cases the following conclusions are drawn: 1. Tobacco, typhus fever, or other previous infection play no part in the etiology. The age of onset is usually in the second or third decade. 2. The acute specific lesion described by Buerger is not found in the vessels of the amputated extremities. The deep arteries and veins in the affected limbs show various stages in the process of organization and recanalization of thrombotic lesions. 3. Acute phlebitis is an uncommon finding. 4. Patients are generally in good health aside from their local condition. 5. The extremity first affected is more often the right lower. 6. Gangrene develops generally within two to five years after onset of symptoms. 7. The disease is characterized by periods of remission from months to years in which the patient may be free from all symptoms. 8. The most important physical sign and indication of arterial occlusion is absent pulsation of palpable arteries of the extremities. This occurs months or years before the onset of gangrene. 9. The capillaries are normal. 10. Arteriosclerosis is sometimes associated with the disease. 11. All four limbs are often involved in the older cases. The cause of death is generally an intercurrent infection. Death from thromboangiitis obliterans of the aorta and coronary vessels may occur. 12. The disease must be differentiated from the other causes of gangrene, principally Raynaud's disease, arteriosclerotic endarteritis, syphilitic endarteritis, and from sclerodactyly. 13. The present treatment is unsatisfactory.—*H. A. Pingree, M.D., Portland, Maine.*

CASE OF VON RECKLINGHAUSEN'S OSTEITIS FIBROSA. A. Rendle Short. *Brit. Jour. of Surg.*, July, 1925, p. 170.

History: Female, 46; had long-standing swelling of right knee and of fingers of right hand. Present swelling of four months duration. Examination showed right knee swollen, with irregular bosses arising from tibia and femur; no fluid present. Right hand showed swelling of phalanges at their bases. Radiogram showed lower end of femur consisted of a thin shell of hard cortex enclosing a nearly uniform transparent tissue extending several inches up the shaft. In front the cortex was perforated by the transparent mass. The upper end of the fibula showed a similar condition. The tibia showed a more localized transparent area which had bulged out through the cortex both behind and in front. The patella retained a hard shell, but the rest of the bone was transparent.

Treatment: After trial of a walking caliper, a wide excision of the knee was performed. Pictures of the bone removed are shown. The tibia was the more grossly diseased. The material occupying the head of the bone was gelatinous in consistency with small pearls and rods of cartilage-like material. It varied in color from greyish pink to a red jelly.

Microscopic Report. (Prof. I. Walker Hall.)

"The tissue shows chiefly the later changes associated with osteitis fibrosa. There is generalized replacement of the bony structure by fibrous tissue."

Discussion: The histologic features of osteitis fibrosa are an erosion and expansion of the bone with the laying down of new bone on fibrous strands which become converted into osseo-mucin. There is a tendency to myxomatous degeneration, and cysts large or small are plentiful.

In osteitis deformans the changes are fundamentally very similar, but the giant-cell areas are absent and the bone changes are more in evidence.

In osteomalacia there is a simple dissolving out of the mineral salts leaving zones of decalcified osteoid tissue. There is little or no fibro-osteoid tissue replacement of the marrow and Haversian spaces and there are few or no osteoclasts.

In myeloid sarcoma (benign giant-celled tumor) there is a definite tumor-formation full of giant cells which are osteoclasts, not myeloplaxes.

Pecularities of the case are: 1. Association with many subcutaneous naevo-fibromata. 2. The absence of fractures. 3. The great pain and the swelling of the knee joint. 4. The scantiness of osteoclasts. 5. The presence of rods and pearls of osseo-mucin.—*Alexander Gibson, F.R.C.S., Winnipeg.*

ETIOLOGY OF KÖHLER'S DISEASE OF THE SECOND METATARSAL BONE. Giovanni Valtancoli, *Chir. degli Org. Movimento*, July, 1925, p. 447.

Valtancoli, with four cases of the so-called Köhler's disease of the second metatarsal bone, gives his opinion concerning the etiology of this affection.

Bossi and Beely have demonstrated that the second metatarsal is the weight bearer of the anterior part of the foot, and Muskat shows that 54.5% of the fractures involving the foot belong to this bone.

The female sex is more affected, perhaps due to the use of the high heels, which, increasing the equinus, expose the second metatarsal more easily to traumatism.

Valtancoli believes that the trauma, violent or slow, but continuous in action

predisposes to the development of this condition. For treatment he recommends immobilization with plaster-of-Paris, then resection of the head if the symptoms subside.—*Felipe Muro, M.D., Farmington, Mich.*

INTERMITTENT CLAUDICATION AND ITS TREATMENT. Vaquez. *Paris Médical*, July 4, 1925, p. 17.

Charcot defined intermittent claudication as a painful weakness in the leg coming on after exercise. It is due to an ischemia from partial obstruction of the principal artery. In extreme cases it may result in gangrene. Claud Bernard has shown experimentally that the quantity of blood necessary in a limb during exercise is six times as great as is required during rest.

A typical case is as follows:

A man of 46 entered the hospital for pain in the right foot and leg, especially in an area near the fifth toe. He was still working, but when walking had to stop about every fifty metres to rest. Pain worse at night. Duration six years with intermissions. Pain momentarily relieved on getting up. Right foot cold, white, and insensible. Roentgenogram negative. Wassermann positive. Somewhat relieved by intravenous injections of sodium citrate. A year later symptoms returned with double intensity. Gangrene finally came on, beginning around the base of the fifth toe. It seemed that amputation would be necessary.

The blood pressure is usually lower on the affected side than on the normal side. The general tension, however, is normal. Syphilis is present in about 30 per cent. of the cases. It has been said that it occurs only in excessive smokers

The pathology is a subject of discussion. There is usually some alteration of the arteries, either iliac aneurysm, arteritis obliteran, or stenosis.

Treatment should be directed to the cause if possible. Iodides should be given if the case shows atheroma. Anti-syphilitic treatment when indicated. Symptomatic treatment may include: sodium nitrate as vaso-dilator; diathermy; citrate of soda intravenous to augment the blood volume, about 250 C.C. of a 2 per cent. solution. Sympathectomy is also indicated in some cases.—*William Arthur Clark, M.D., Pasadena, Calif.*

HISTOLOGY AND PATHOLOGY OF PERTHES' DISEASE AND ASEPTIC CARTILAGE-BONE NECROSIS IN GENERAL. Herman Walter. *Archiv. f. Orthop. und Unfall-Chir.*, Bd. 23, H. 5, 1925.

The manifold diseases described under various names characterized by the aseptic necrosis of bone and cartilage are clinically and pathologic-anatomically identical. They are not explainable by a single or chronic trauma, but they suppose a pre-existing inner damage to the tissues. On the basis of many theoretical and demonstrable facts, the author adheres to the theory of Axhausen that an embolic mycotic closure of the arteries is the actual factor in the formation of the necrosis. Hypoplastic bone systems seem to be preferred as a selection of the necrotic site. The course of the disease is chronic and does not necessarily lead to healing: it may terminate in an ankylosis of the affected joint after it has gradually grown worse and worse. Histologically it presents the picture of a chronic inflammatory-fibrous degeneration of the bone-marrow with rarefication of bone structure and secondary damage to the articular cartilage which may totally necrose and disappear.—*A. Gottlieb, M.D., Los Angeles.*